# 3.8 SPECIAL-STATUS SPECIES

## 3.8.1 INTRODUCTION

This section identifies potential effects of proposed interim surplus criteria to aquatic and terrestrial species of concern and their habitat, from Lake Powell to the SIB. Potential impacts to special-status species in Mexico are discussed in Section 3.16, Transboundary Impacts. As discussed in Section 1.4, a considerable amount of information pertinent to this analysis is available from various documents prepared by Reclamation and the Service under NEPA and/or the ESA, and is incorporated by reference.

Special-status species are species that are listed, or are proposed for listing, as "threatened" or "endangered" under the federal ESA that may be present in the area affected by the proposed action, and also include species of special concern to states or other entities responsible for management of resources within the area of analysis. This section contains a discussion of the life history requirements of each species, followed by an analysis of potential impacts to the species and its habitat.

Reclamation is consulting with the Service (and NMFS) to meet its responsibilities under Section 7 of the ESA on the effects of the proposed action to federally listed species. Reclamation prepared a biological assessment (BA) which evaluates the potential effects on listed species which may occur in the area from the headwaters of Lake Mead to the SIB (Reclamation, 2000). Preliminary evaluation of the effects to listed species which may be present in the Colorado River corridor from Glen Canyon Dam to the headwater of Lake Mead led to the conclusion that the interim surplus criteria would not affect any species. Therefore, this area was not addressed in the BA. Refinements to the model used to predict future operations of Glen Canyon Dam for this EIS indicated there would be a minor change in the frequency with which flows recommended by the 1994 biological opinion concerning operation of Glen Canyon Dam would be triggered. It was determined that this change may affect listed species. The results of this analysis were provided to the Service in a November 29, 2000 memorandum as supplemental information to the BA, which is included in Attachment S.

Potential impacts to special-status species occurring in Mexico are discussed separately in Section 3.16, Transboundary Impacts. Specifically, Section 3.16 considers the potential effects on the following species: desert pupfish, vaquita, totoaba, Southwestern willow flycatcher, Yuma clapper rail, yellow-billed cuckoo, California black rail, elf owl, Bell's vireo, and Clark's grebe. Although consultation on species occurring in Mexico may not, as a matter of law, be required by the ESA, Reclamation is also supplementing the BA to include information pertinent to federally listed species from this analysis.

## 3.8.2 METHODOLOGY

Information on the affected environment and special-status species that may occur in the analysis area was compiled based on review of the pertinent documents listed in Section 1.4, available published and unpublished literature, and through personal communication with agency resource specialists. Species' distribution, range and habitat requirements were reviewed. These requirements formed the basis for compiling an initial list of plant, wildlife and fish species to be considered.

This analysis first discusses vegetative communities that exist throughout the analysis area, from Lake Powell to the SIB. Potentially affected plant, wildlife and fish species are then determined by considering hydrologic requirements and other habitat elements important to the species, such as nesting or breeding habitat for birds and spawning and rearing areas for fish. Species that are not known to be present in the analysis area, do not depend on terrestrial or aquatic habitat associated with the area under consideration or have a hydrologic connection are addressed briefly and removed from further consideration. The analysis of effects to the remaining potentially affected plant, animal and fish species and their habitat follows the section on the affected environment.

## 3.8.3 AFFECTED ENVIRONMENT

Vegetative communities within the analysis area are discussed, based on if they are located alongside the reservoirs (lakeside habitat) or along the Colorado River (riverside habitat). The special-status species are then identified. The species are divided into three main categories: plants, wildlife and fish. Tables in this section list the species' common and scientific names and current status, and indicate if critical habitat has been federally designated. Following each table, the occurrence and requirements of the species is provided. Species that would not be affected by the interim surplus criteria are identified and removed from further analysis.

### 3.8.3.1 LAKE AND RIPARIAN HABITAT

A description of lakeside vegetation associated with Lake Powell and GCNRA is provided below, followed by a description of vegetation associated with Lake Mead and LMNRA (which includes Lake Mohave) and Lake Havasu. This section then describes riverside habitat along the Colorado River corridor from Separation Canyon to the Lake Mead delta and below Hoover Dam. Aquatic habitat is discussed in the previous section on Aquatic Resources (Section 3.7).

#### 3.8.3.1.1 Lakeside Habitat

Riparian and marsh vegetation around Lake Powell and Lake Mead is extremely restricted because of the desert terrain that extends directly to the water's edge (Reclamation, 1999d), and the continuously fluctuating lake levels that precludes establishment of vegetation. Tamarisk or salt cedar (*Tamarix ramosissima*), a non-native invasive shrub- to tree-like plant along the Lake Powell shoreline is still becoming established and has not yet formed stable ecosystems. These communities will probably attain some importance as insect and wildlife (particularly bird) habitat in the future, and already provide habitat for fish during high lake levels when the plants are inundated (NPS, 1987).

Small intermittent or seasonal streams occur in many of the side canyons of Lake Powell. Fluctuations in lake levels may result in standing water in these side canyons where riparian vegetation has become established. Dominant plants found in these canyons include Fremont cottonwood (*Populus fremontii*), tamarisk, and cattail (*Typha* sp.) (NPS, undated b). The vegetation within these side canyons has been altered by the lake itself as a result of periodic inundation in association with fluctuating lake levels. In areas where there are springs and seeps, cattail marshes may be found. The most serious adverse influence on canyon and spring riparian zones associated with intermittent or seasonal streams in the side canyons of Lake Powell is domestic and feral livestock use (NPS, 1987).

The GCNRA also has many springs, seeps that are common in alcoves along the canyon walls, and waterpockets located in canyons and uplands. These areas are recognized for their significance as wetland habitats and as unique ecosystems within the desert (NPS, 1987).

The seeps that are common in alcoves along the walls of the canyon support hanging gardens. Hanging gardens are a specialized vegetation type and have a unique flora associated with them. The water sources that support hanging gardens originate from natural springs and seeps within the Navajo sandstone formation and are independent of Lake Powell. This plant community is found at various elevations around Lake Powell and is typically not affected by reservoir fluctuations. GCNRA hanging gardens are characterized by Eastwood monkeyflower (*Mimulus eastwoodiae*), alcove columbine (*Aquilegia micrantha*), Rydberg's thistle (*Cirsium rydbergii*) and alcove primrose (*Primula specuicola*). None of these are special-status species at this time, although all four are endemic to the Colorado Plateau. Maidenhair fern (*Adiantum* sp.) is the most typical species in hanging gardens throughout the Plateau (Spence, 1992). Other species typically associated with hanging gardens include maidenhair fern, golden columbine (*Aquilegia chrysantha*) and scarlet monkeyflower (*Mimulus cardinalis*).

The highest concentration of habitat associated with Lake Mead in the LMNRA is found in the Lake Mead and Virgin River deltas. Linear riparian woodlands may be present along the shoreline of the Lake Mead delta following high water flows, and associated sediment deposition and exposure. The sediment deposition and the associated growth of riparian vegetation at the Lake Mead delta has occurred for decades (McKernan, 1997). When lake levels decline, vegetation in the Lake Mead and Virgin River deltas begins to establish on clay/silt deposits. The dynamic nature of fluctuating lake levels and deposition of sediment in the Lake Mead delta is expressed as a change in plant species composition and relative abundance over time. In 1963, tamarisk was the dominant tree species in the Lake Mead delta (McKernan, 1997). In 1996, habitat descriptions for Southwestern willow flycatcher study sites at the Lake Mead delta reported 95 percent of the vegetation as willow or cottonwood with only five percent as tamarisk (McKernan, 1997). An increase in sediment deposition in the deltas followed by lower lake levels allows establishment of native riparian habitat if the lowering of the lake is timed to match native seed dispersal. As such, conditions for establishment of native vegetation at the Lake Mead delta have improved since 1963 allowing cottonwood and willow to become the dominant vegetation.

Germination of willows at the Lake Mead delta likely occurred in the spring of 1990 at the approximate water surface elevation of 1185 feet msl (McKernan, 1997 and Reclamation, 1998c). The water surface elevations in 1996 and 1997 were 1192 feet and 1204 feet, respectively (Reclamation, 1998c). These higher lake levels inundated willow habitat in the Lake Mead delta and the Lower Grand Canyon (McKernan, 1997). Until 1998, the Lake Mead delta contained an extensive growth of riparian vegetation principally composed of Goodding willow (*Salix gooddingii*) (McKernan, 1997). By 1999 the Lake Mead delta willow habitat was completely inundated. To a lesser degree, these same effects may also be seen at the Virgin River delta. A higher delta gradient at the Virgin River delta results in a shorter period of inundation at high (greater than 1192 feet msl) lake levels (Reclamation, 1998c).

Section VI of the BA (Reclamation, 2000) provides additional information on fluctuations in lake levels and development of riparian habitat at Lake Mead. It notes that determining exactly how many acres of riparian habitat that may be formed due to declining levels at Lake Mead under the proposed interim surplus criteria is problematic. It further states that the majority of the Lake Mead shoreline does not have the soil necessary to regenerate riparian habitat, and that riparian habitat created by declining lake levels would most likely occur in four areas: Lake Mead delta, Virgin River delta, Muddy River delta and the portion of the Lower Grand Canyon influenced by Lake Mead. However, future wet hydrologic cycles, would inundate the newly established riparian habitat.

Although higher lake levels may be detrimental to riparian vegetation at the Lake Mead and Virgin River deltas, it may be beneficial to the development of riparian habitat in the lower Grand Canyon downstream of Separation Canyon, and the Virgin and Muddy rivers above Lake Mead (Reclamation, 1998c). Riparian habitat extends from the lake deltas upstream into the lower Grand Canyon and Virgin River Canyon. Development of riparian habitat in these canyons is directly dependent upon fluctuating lake levels and periods of inundation in the canyons. Data collected on riparian vegetation from 1998 Southwestern willow flycatcher surveys (McKernan, 1999) indicate a well-developed riparian corridor composed primarily of willow (*Salix* spp.) and tamarisk that forms extensive and continuous stands in some portions of the lower Grand Canyon. Lower water levels in Lake Mead that expose sediments in the Lake Mead, Virgin River and Muddy River deltas have the potential to benefit establishment of riparian habitat in these areas. However, lower water levels in Lake Mead do not benefit establishment of riparian and marsh habitat in the lower Grand Canyon. In order for riparian and marsh habitats to become established along the Colorado River in the lower Grand Canyon, higher water levels in Lake Mead are necessary.

A few literature sources briefly examine influences of fluctuating lake levels on marsh habitat at the Lake Mead and Virgin River deltas. In 1995, the Lake Mead delta supported hundreds of acres of cattail and bulrush marsh (Reclamation, 1996a). This vegetation type increased after a period of high flows from 1983 to 1986. Deposits containing clay/silt sediments are necessary for the development of emergent marsh vegetation (Stevens and Ayers 1993). Low water velocity sites, such as the Lake Mead and Virgin River deltas, permit clay/silt particles to settle from suspension. These deposits provide a higher quality substrate for seed germination and seedling establishment than underlying sand because of their greater nutrient levels and moisture-holding capacity. With the appropriate water regime (i.e., higher river flows during winter with lower flows during summer), these sites are more likely to support emergent marsh vegetation (Reclamation, 1995b). Marsh vegetation that develops during low lake periods would be lost during periods of high lake levels; however, this habitat is more likely than cottonwood/willow to reestablish as lake levels fluctuate (Reclamation, 1996a). Marsh vegetation that develops during low lake levels is important habitat for many species, particularly breeding birds.

The interim surplus criteria BA (Reclamation, 2000) provides additional information on fluctuations in lake levels and development of riparian habitat at downstream reservoirs (Lake Mohave and Lake Havasu). The interim surplus criteria are not expected to affect levels of the downstream reservoirs as they would be continue to be regulated to meet downstream flood control, power generation and water delivery purposes.

#### 3.8.3.1.2 Riverside Habitat

The riparian vegetation along the Colorado River is among the most important wildlife habitat in the region. Though not common, springs can be found within the GCNRA in intermittent drainages where they often support wetland plant communities. Between Glen Canyon Dam and Lees Ferry, springs are created by several spontaneous, copious flows from the lower canyon walls (NPS, 1987). The *Water Resources Management Plan and Environmental Assessment* for the GCNRA speculates that this spring flow originates from Lake Powell bank storage in the Navajo Sandstone (NPS, 1987), and thus, this area could be affected by changes in Lake Powell surface levels. Overall, lower lake levels are not likely to have any impacts on gardens around Lake Powell, but may have some impacts on springs directly associated with Glen Canyon Dam and extending downriver approximately two to three miles. In the lower canyon, arrowweed *(Pluchea sericea)* and horsetail are common. Below Havasu Creek, bermuda grass becomes the dominant ground cover at many sites (Reclamation, 1996a).

Mesquite (*Prosopis glandulosa*) historically occurred on the broad alluvial floodplains of the Colorado River on secondary and higher terraces above the main channel (LCRMSCP, undated). It still is a dominant species above the scour zone through the Grand Canyon (Ohmart et al., 1988; Turner and Karpiscak, 1980); however, tamarisk is replacing mesquite in many areas along the Colorado River.

Catclaw acacia occurs along watercourses and other areas where a summer water supply may be present (Barbour and Major, 1995; Brown, 1994; Holland, 1986; Sawyer and Keeler-Wolf, 1995). This species occurs in both upland and riparian vegetation associations (Reclamation, 1996a). Catclaw acacia in the Grand Canyon can occur with Apache plume (*Fallugia paradoxa*), a typical constituent in the acacia-mesquite habitat. It may also be found with desert broom (*Baccharis* spp), which is an obligate riparian species that occurs in the cottonwood-willow habitat type (Turner and Karpiscak, 1980).

Two types of marsh plant associations have been identified along the Colorado River (Stevens and Ayers, 1991). Marshes were historically found along oxbow lakes and in backwater areas along the Colorado River. Cattails, bulrushes, common reed and some less common emergent plants occur in marsh areas that develop on sediment deposits containing about half clay/silt and half sand (Reclamation, 1995).

In the lower Grand Canyon above Lake Mead, the interim surplus criteria may affect backwater marshes due to the changes in water levels. These changes in water levels could affect temperature and other water quality considerations, as well as the establishment of marsh vegetation. Section V of the BA (Reclamation, 2000) discusses historic and existing marsh, backwater and aquatic habitat on the lower Colorado River below Hoover, Davis and Parker dams.

### 3.8.3.2 SPECIAL-STATUS PLANT SPECIES

The list of special-status plants in Table 3.8-1 below is based on documented or potential occurrence within vegetation communities of the Glen Canyon National Recreation Area (GCNRA), Lake Mead National Recreation Area (LMNRA) and the Colorado River corridor in the lower Grand Canyon. No special-status plant species were identified for analysis below Hoover Dam. Nineteen plant species were removed from detailed consideration, as discussed in the next section. Four species could be affected by interim surplus criteria alternatives and are considered further.

**Table 3.8-1**
**Special-Status Plant Species Potentially Occurring Within the Area of Analysis**

| Common Name | Scientific Name | Status |
|---|---|---|
| Alcove bog orchid | *Habenaria zothecina* | Federal Species of Concern |
| Alcove daisy | *Erigeron zothecinus* | Federal Species of Concern |
| Alcove deathcamas | *Zigadenus vaginatus* | Federal Species of Concern |
| Barrel cactus | *Ferrocactus acanthodes var. lecontei* | Northern Nevada Native Plant Society (NNNPS) Watch List species and Listed as Sensitive by the Service (Intermountain Region) |
| Brady's footcactus | *Pediocactus bradyi* | Federally Listed Endangered |
| Canyonlands sedge | *Carex scirpoidea var. curatorum* | Federal Species of Concern |
| Geyer's milkvetch[1] | *Astragalus geyeri var. triquetrus* | Federal Species of Concern; Nevada Critically Endangered |
| Grand Canyon evening-primrose[1] | *Camissonia specuicola ssp. Hesperia* | Federal Species of Concern |
| Hole-in-the-Rock prairie clover | *Dalea flavescens* | Federal Species of Concern |
| Jones cycladenia | *Cycladenia humilis var. jonesii* | Federally Listed Threatened |
| Kachina daisy | *Erigeron kachinensis* | Federal Species of Concern |
| Las Vegas bear poppy[1] | *Arctomecon californica* | Nevada Listed Critical Endangered |
| Navajo sedge | *Carex specuicola* | Federally Listed Threatened |
| New Mexico raspberry | *Rubus neomexicana* | Federal Species of Concern |
| Rock Daisy | *Perityle specuicula* | Federal Species of Concern |
| Rosy bicolored beardtongue | *Penstemon bicolor ssp. Roseus* | Federal Species of Concern |
| Satintail grass | *Imperata brevifolia* | Federal Species of Concern |
| Sawgrass | *Cladium californicum* | Federal Species of Concern |
| Sticky buckwheat[1] | *Eriogonum viscidulum* | Federal Species of Concern |
| Thompson's indigo-bush | *Psorothamnus thompsoniae var. whittingii* | Federal Species of Concern |
| Ute ladies' tresses | *Spiranthes diluvialis* | Federally Listed Threatened |
| Virgin River thistle | *Cirsium virgenense* | Federally Listed Species of Concern; Arizona Salvage-restricted, Protected Native Plant |
| Western hophornbeam | *Ostrya knowltonii* | Federal Species of Concern |

[1] Species with the potential to be affected by the interim surplus criteria that are considered further

#### 3.8.3.2.1 Plant Species Removed from Further Consideration

This section discusses the reasons for eliminating certain special-status plant species from detailed consideration.

Special-status plant species that occur in hanging gardens at GCNRA include alcove bog orchid, alcove daisy, alcove deathcamas, canyonlands sedge, Kachina daisy, Navajo sedge, New Mexico raspberry, sawgrass, western hophornbeam and Virgin River thistle. The water source for these species comes from seepage from the Navajo sandstone that would not be affected by hydrologic changes associated with interim surplus criteria.

Barrel cactus, Brady's footcactus, rosy bicolored beardtongue, Jones cycladenia and Thompson's indigo-bush are desert species. This habitat type and associated plant species would not be affected by interim surplus criteria.

Hole-in-the-Rock prairie clover occurs in the Hall's Creek and Escalante drainages in the GCNRA, which would not be affected by hydrologic changes associated with the interim surplus criteria.

Rock daisy occurs at Cedar Mesa in GCNRA, growing in sandstone along the margins of an ephemeral stream channel at the canyon bottom that would not be affected by interim surplus criteria.

Satintail grass occurs within lower Wilson's Creek in the GCNRA, an area that would not be affected by interim surplus criteria.

Sawgrass has been found in the riparian zone of Alcove Canyon in Grand Canyon National Park, and in the riparian zone of Garden Canyon on the cliffs above Lake Powell. These riparian zones would not be affected by interim surplus criteria.

Ute ladies' tresses occur in moist to wet meadows along perennial streams at elevations between 4,300 and 7,000 feet msl. These occurrences are above those elevations that occur within the area under consideration. As such, this species would not be affected by interim surplus criteria.

Virgin River thistle occurs on sandy or gravelly alkaline slopes and washes and around saline seeps, alkaline springs or stream terraces. It occurs between elevations of 1968 and 6562 feet msl, and is associated with Mojave mixed scrub habitat. This habitat type would not be affected by interim surplus criteria. As such, this species would not be affected by interim surplus criteria.

#### 3.8.3.2.2 Plant Species Considered Further

**Geyer's Milkvetch** - Geyer's milkvetch is known to occur along the shoreline of Lake Mead and is associated with stabilized sand dunes and sandy soils. Population trends have not been well documented for Geyer's milkvetch. Germination may be tied to rainfall, and poor seed production and insect infestations may contribute to the limited distribution and/or small population sizes observed for this variety (Mozingo and Williams, 1980). Some populations have been directly affected by rising water levels at Lake Mead (i.e., Middle Point). Additional causes of decline for this taxon may include shoreline recreation, trampling and grazing by burros and livestock, off-road vehicle use, and utility corridors (Niles et al., 1995).

Threats to Geyer's milkvetch in the study area have not been well defined. This variety may be potentially threatened by: 1) loss of habitat from inundation and rising water levels at Lake Mead; 2) invasion of shoreline (beach) habitat by other plant species (i.e., tamarisk and arrowweed); and possibly 3) trampling and grazing by burros. Geyer's milkvetch occurs further back from the shoreline and may be less affected by these factors (E. Powell, 2000). Shoreline recreation does not currently appear to be a major threat to this species because the beaches where it occurs do not receive heavy recreational use. In addition, the species typically flowers and sets seed prior to the beginning of heavy use periods at Lake Mead (Niles et al., 1995; E. Powell, 2000). However, rising lake levels may potentially affect this species directly by inundation of plants or indirectly through inundation of suitable habitat.

**Grand Canyon Evening Primrose -** Grand Canyon evening primrose is a clustered herbaceous perennial plant with small flowers that are yellow or white at anthesis (flowering), but may turn to pink or lavender with aging. The Grand Canyon evening primrose occurs on beaches along or near the main stem Colorado River in the vicinity of Separation Canyon and downstream of Diamond Creek where available beach habitat is exposed (Brian, 2000 and Phillips, 2000). This species is likely adversely affected when beaches are disturbed through erosion or deposition of sediments during flood events. Some degree of flooding occurs seasonally as the result of increases in side-channel inflows during rainfall events. Additional flood flows result from periodic BHBF releases from Glen Canyon Dam. The degree to which flooding adversely affects this subspecies and which water levels are detrimental to the plants and its habitat is unknown. However, the amount of beach habitat in the Grand Canyon has decreased under post-dam conditions, and the remaining habitat is often invaded by riparian vegetation (Schmidt et al., 1998). Because this subspecies is found on good camping beaches, particularly in the lower portion of the Grand Canyon, it may also be adversely affected by disturbance associated with recreational beach use; however, this potential effect is not related to the interim surplus criteria.

**Las Vegas Bear Poppy -** Las Vegas bear poppy is a short-lived perennial species, occurring along the lower levels of the Lake Mead shoreline (E. Powell, 2000). This plant occurs on gypsum soils below the high water line of Lake Mead (1225 feet msl) on sloping flats. Little is known about the life cycle of the Las Vegas bear poppy, and populations vary in a "boom or bust" pattern (E. Powell, 2000). This species would benefit from lower water levels at Lake Mead, and could be adversely affected by increases in water levels although timing of water fluctuations and associated effects to this species are unknown.

**Sticky Buckwheat** - Sticky buckwheat is found primarily along the Overton Arm of Lake Mead (Reveal and Ertter 1980, Niles et al., 1995). Smaller, potentially significant populations occur in the vicinity of Overton Beach, along the Virgin River Valley, and along the Muddy River. Major threats to sticky buckwheat at Lake Mead include: 1) loss of habitat from inundation and rising water levels at Lake Mead; 2) invasion of shoreline (beach) habitat by other plant species (i.e., tamarisk and arrowweed); and possibly three) trampling and grazing by burros. Shoreline recreation does not currently appear to be a major threat to this species because the beaches where it occurs do not receive heavy recreational use. In addition, the species typically flowers and sets seed prior to the beginning of heavy use periods at Lake Mead (Niles et al., 1995). This species would benefit from lower water levels at Lake Mead, and could be adversely affected by increases in water levels.

### 3.8.3.3 SPECIAL-STATUS WILDLIFE SPECIES

Special-status wildlife species with the potential to occur within the area under consideration in the United States are listed in Table 3.8-2. Two invertebrate, two amphibian, and one reptile species are of concern. Eleven bird species and two mammals are of concern. A number "1" after the species on the table indicates the species has the potential to be affected by the interim surplus criteria alternatives, and is therefore assessed in more detail.

**Table 3.8-2**
**Special-Status Wildlife Species Potentially Occurring Within the Area of Analysis**

| Common Name | Scientific Name | Status |
|---|---|---|
| **Invertebrates** | | |
| MacNeill's sootywing skipper | *Hesperopsis gracielae* | Federal Species of Concern |
| Kanab ambersnail | *Oxyloma haydeni kanabensis* | Federally Listed Endangered; Arizona Wildlife of Special Concern |
| **Amphibians** | | |
| Northern leopard frog | *Rana pipiens* | Arizona Candidate for Listing |
| Relict leopard frog | *Rana onca* | Nevada State Protected; Arizona Wildlife of Special Concern |
| **Reptiles** | | |
| Sonoran mud turtle | *Kinosternon sonoriense sonoriense* | California Species of Special Concern |
| **Birds** | | |
| American peregrine falcon | *Falco peregrinus anatum* | California Endangered; Nevada State Protected and Endangered |
| Arizona Bell's vireo[1] | *Vireo bellii arizonae* | California Endangered |
| Bald eagle[1] | *Haliaeetus leucocephalus* | Federally Listed Threatened; California Endangered; Nevada State Protected and Endangered |
| California black rail[1] | *Laterallus jamaicensis coturniculus* | Federal Species of Concern; California Threatened |
| Clark's grebe[1] | *Aechmophorus clarkii* | Arizona Wildlife of Special Concern |
| Cooper's hawk[1] | *Accipiter cooperii* | California Species of Special Concern |
| Elf owl[1] | *Micrathene whitneyi* | California Endangered |
| Gilded flicker[1] | *Colaptes chrysoides* | California Endangered |
| Southwestern willow flycatcher[1] | *Empidonax traillii extimus* | Federally Listed Endangered (critical habitat designated); California Endangered; Nevada State Protected |
| Yuma clapper rail[1] | *Rallus longirositris yumaniensis* | Federally Listed Endangered; California Threatened |
| Western yellow-billed cuckoo[1] | *Coccyzus americanus* | Federally Proposed Endangered; California Endangered; Nevada State Protected |
| **Mammals** | | |
| Colorado River cotton rat | *Sigmodon arizonae plenus* | Federal Species of Concern; California Species of Special Concern |
| Occult little brown bat | *Myotis lucifugus occultus* | Federal Species of Concern; California Species of Special Concern |

[1] Species with the potential to be affected by the interim surplus criteria that are considered further in this analysis

### 3.8.3.3.1 Wildlife Species Removed from Further Consideration

The Kanab ambersnail occurs in semi-aquatic habitat associated with springs and seeps. In the Grand Canyon, Kanab amber snail were originally known to occur only at Vasey's Paradise, a large perennial spring. As part of an effort to recover the species, Kanab amber snails were translocated from Vasey's Paradise to three other locations. One of the criteria used to select these sites was that it be above the level of any potential future flood flows past Glen Canyon dam. These populations would not be affected by the adoption of interim surplus criteria. Reclamation has consulted with the Service on the effects to the Vasey's Paradise population from the operations of Glen Canyon Dam. The resulting biological opinion (USFWS, 1996) continues to be implemented and will not be affected by the proposed action. There will be no effect from the adoption of interim surplus criteria.

The northern leopard frog is known to occur in association with a spring at one site below Glen Canyon Dam. The population was monitored before and after the 1996 BHBF and found to persist under these flows. This species receives consideration under the Glen Canyon Dam AMP (see Section 3.2.2). The minor changes to operations of Glen Canyon due to adoption of the interim surplus criteria are not expected to affect the northern leopard frog.

Historically, the relict leopard frog (*Rana onca)* was known from several locations along the Virgin river, and from the Overton arm of Lake Mead to north of St. George, Utah. This species was also known from the Muddy River and Meadow Valley Wash in Nevada, northwest of the Overton Arm. This species was thought to be extinct, but was rediscovered at three of 51 potential habitat sites surveyed in 1991. Surveys conducted for relict leopard frog included potential habitat within the historical range of the species (Bradford and Jennings 1997). There are confirmed sightings of this species at springs about two miles (3.2 km) west of Stewarts Point on the Overton Arm of Lake Mead. A fourth population of leopard frog on the Virgin River near Littlefield, Arizona is within the range of the lowland leopard frog (*R. yavapaiensis)* and is still awaiting additional studies to confirm its taxonomic status. Other unconfirmed sightings are on the Virgin River near Littlefield, Arizona and about four km (2.5 miles) downstream from Hoover Dam.

In general, leopard frogs inhabit springs, marshes, and shallow ponds, where a year-round water supply is available. Emergent or submergent vegetation such as bulrushes or cattails provides the necessary cover and substrate for cover and oviposition (Jennings et al., 1994). Suitable aquatic habitat, as well as, adjacent moist upland or wetland soils is required by the relict leopard frog. In addition, dense herbaceous cover and a canopy of cottonwoods or willows characterize habitat for this species.

The relict leopard frog populations located near the Overton Arm of Lake Mead are associated exclusively with geothermally influenced and perennial desert spring communities. Because the known populations are currently confined within a five-mile

(8km) area (Bradford and Jennings 1997), they are susceptible to extirpation from localized impacts. Threats to this species include habitat destruction, lowering of the water table, and predation by introduced bullfrogs (AGFD, 1996; AGFD 1998).

The known occurrences of relict leopard frogs are in association with springs that will not be affected by the interim surplus criteria alternatives being considered. If additional emergent marsh vegetation develops at the Lake Mead and Virgin River deltas as the result of lower lake levels, it may provide potential habitat for the relict leopard frog. However, predation by introduced fishes and bullfrogs may preclude occurrence of the leopard frogs in these areas. Reclamation concludes that the interim surplus criteria do not have the potential to affect the relict leopard frog.

MacNeill's sootywing skipper is a butterfly found along the Colorado River from southern Utah and Nevada to Arizona and southeastern California (Reclamation, 1996a). Confirmed records of this species are reported for the Arizona counties of Mohave, La Paz, Yuma, Yavapai, Maricopa and Pinal. The MacNeill's sootywing skipper is also present in San Bernardino, Riverside and Imperial counties in California. This species also occurs along the Muddy River above Lake Mead (Austin & Austin, 1980).

The larval host plant for MacNeill's sootywing skipper is quailbrush (*Atriplex lentiformis*). Quailbrush is the largest salt bush found in Arizona and forms dense thickets along the drainage system of the Colorado River (Emmel and Emmel, 1973). Quailbrush is associated with floodplains located in alkaline soil areas with adequate water resources (Kearney and Peebles, 1951). Specific surveys for this species and larval host plants have not been conducted in the lower Grand Canyon; however, the documented occurrence of MacNeill's sootywing skipper along the Muddy River above Lake Mead indicates there is a likelihood of occurrence in the lower Grand Canyon. Suitable habitat for this species likely requires stands of more than one host plant (W. Wiesenborn, 1999). Although this species occurs in the area of analysis, the host plant occurs on alluvial floodplains and has little potential to be affected by the alternatives considered for the interim surplus criteria.

Lake Powell and Lake Mead provide breeding and wintering habitat for American peregrine falcons. The peregrine falcon breeds at sites on Lake Mead, and the upper portion of Lake Mohave. Wintering and breeding peregrines are also found around Lake Powell, with an estimated 50 breeding areas (Interior, 1995), and 19 wintering territories (Hetzler, 1992a). Based on historical data, the average height above water of peregrine nests at GCNRA is approximately 460 feet (141 meters), with average cliff heights of 630 feet (193 meters) (Hetzler 1992a, Hetzler 1992b). These data include nest sites in Glen Canyon immediately below the Glen Canyon Dam as well as sites on Lake Powell. Glen Canyon Dam operations have resulted in increased riparian vegetation which supports a larger population of passerines and increased the food base for peregrine falcons.

Existing and potential American peregrine falcon breeding habitat also occurs in the Grand Canyon between Glen Canyon Dam and Lake Mead and in Black Canyon, (south of Lake Mead). Because their nesting sites are well above the water and their food base has increased, peregrine falcons would not be affected by hydrologic changes associated with the interim surplus criteria and have been eliminated from further analysis.

The Sonoran mud turtle, Colorado River cotton rat, and occult little brown bat were removed from further consideration because there are no known occurrences in the analysis area.

### 3.8.3.3.2 Special-Status Wildlife Species Considered Further

**Arizona Bell's Vireo** - The Arizona Bell's vireo (*Vireo bellii arizonae*) is distributed throughout the river systems of the Southwest desert and have been documented in the Virgin and Muddy rivers, and the lower Colorado River. Since 1900, populations of this subspecies of Bell's vireo have declined along the lower reaches of the Colorado River, where it is now a rare, to locally uncommon, summer resident from Needles south to Blythe (Brown et al., 1983; Zeiner et al., 1990a; Rosenberg et al., 1991). Since the completion of Glen Canyon Dam in 1963, the Bell's vireo has expanded its range eastward into Grand Canyon National Park (Brown et al., 1983). An extensive riparian scrub, that has developed along the Colorado River in the Grand Canyon largely composed of tamarisk and willow, supports a significant population of Bell's vireo (Brown et al., 1983). The Grand Canyon population of Bell's vireo is regionally important due to the substantial decline of this subspecies at lower elevations. The riparian habitat utilized by Arizona Bell's vireo may potentially be affected by the interim surplus criteria

**Bald Eagle** - The bald eagle historically ranged throughout North America except extreme northern Alaska and Canada and central and southern Mexico. In 1978, in response to lowering population and reproductive success, the Service listed the bald eagle throughout the lower 48 states as endangered except in Michigan, Minnesota, Wisconsin, Washington and Oregon, where it was designated as threatened (43 FR 6233, February 14, 1978). In 1982, a recovery plan was developed specifically for the southwestern bald eagle; the geographic boundary includes southeast California within 10 miles of the Colorado River or its reservoirs. The bald eagle population has clearly increased in number and expanded its range since it was listed. This improvement is a direct result of the banning of DDT and other persistent organochlorines, habitat protection, and from other recovery efforts (60 FR 36001, July 12, 1995). On August 11, 1995, FWS reclassified the bald eagle from endangered to threatened in the lower 48 states. (60 FR 133, pg. 3600, August 12, 1995).

Reclamation's 1996 BA concluded that its Lower Colorado river operations and maintenance activities are not likely to adversely affect the food resources, foraging opportunities, or the nesting habitat of the bald eagle. Based on data from bald eagle winter counts conducted by the AGFD since 1992, eagles are not considered rare within the project area. Wintering birds are expected to continue using the river and most likely will congregate where food resources are plentiful and excessive disturbance from recreation can be avoided. The 1996 BA also cites studies by Hunt et al., (1992) that conclude reservoirs and dams did not appear to have a negative effect on bald eagle reproduction. River operations and maintenance may affect establishment of newly regenerated cottonwood/willow stands that could provide future nesting and perching substrate for eagles. However, as documented in Hunt et al. (1992), bald eagles can successfully nest on other substrates (cliffs, pinnacles). Reclamation's ongoing native riparian plant restoration program has the potential to increase available tree nesting and perching habitat along the river. No evidence exists to suggest that the food resources available in the reservoirs and river are limiting nesting. Because of the minor changes to the operation of Glen Canyon Dam and the minor hydrologic changes in the reservoirs and along the river, Reclamation determined that adoption of the interim surplus criteria would not adversely affect the bald eagle.

**California Black Rail** - California black rail (*Laterallus jamaicensis coturniculus*) have recently been documented in the Virgin River Canyon, including the corridor above Lake Mead (McKernan, 1999). In general, Flores and Eddleman (1995) found that black rails utilize marsh habitats with high stem densities and overhead coverage that were drier and closer to upland vegetation than randomly selected sites. Marsh edges with water less than 2.5 centimeters (1 inch) deep dominated by California bulrush and three-square bulrush (*Scirpus californicus* and *S. americanus*, respectively) are utilized most frequently. Areas dominated by cattail are also used regularly, but only in a small proportion to their availability and generally within 50 meters (164 feet) of upland vegetation where water depth is 3.0 centimeters (1.2 inch). The occurrence and potential impacts to species along the river corridor in Mexico are also discussed in Section 3.16.

**Clark's Grebe** – Clark's grebes (*Aechmophorus clarkii*) are typically less abundant than the western grebe at most locations throughout their range (Ratti, 1981; Zeiner et al., 1990a). A 1977 winter survey found Clark's grebes comprised less than 12 percent of *Aechmophorus* grebe sightings at locations within California and areas near Lake Mead (Ratti, 1981). At Lake Mead, a total of 321 western grebes were detected during the winter, while only three Clark's grebes were observed. At Lake Havasu, western grebes are also more abundant than Clark's grebes in the winter. However, Clark's grebes are more numerous in the breeding season, making up approximately 65 percent of the breeding colony (Rosenberg et al., 1991). Although the cattail and bulrush marsh habitat found at the Lake Mead delta exhibits characteristics preferred by Clark's grebe, it is not known whether this species currently occurs at the delta. The marsh habitat at the Lake Mead and Virgin River deltas, and in the Colorado and Virgin rivers above Lake Mead may potentially be utilized by Clark's grebe and may be affected by the interim surplus criteria.

**Cooper's Hawk** – Cooper's hawks (*Accipiter cooperii*) are associated with deciduous mixed forests and riparian woodlands and nests mainly in oak woodlands, but also use willow or eucalyptus woodlands. The Cooper's hawk nests near streams and prefers mature trees with a well-developed understory for nesting sites (Ziener et al., 1990a). Breeding activity has been documented in the lower Grand Canyon, below Separation Canyon, and in the lower Virgin River above Lake Mead (McKernan, 1999). The riparian habitat currently utilized by Cooper's hawk in the lower Grand Canyon and lower Virgin River may be affected by the interim surplus criteria.

**Elf Owl** – The elf owl (*Micrathene whitneyi*) is a secondary cavity nester and, as a result, the population status of the elf owl is directly dependent on available nesting holes in trees made by woodpeckers. As an insectivore, the elf owl is also dependent on sufficient numbers of insects during the breeding season (Johnsgard, 1988). In California, at the extreme northwest edge of its range, the elf owl is likely declining in the few desert riparian habitats that it occupies (Johnsgard, 1988). There may also be a general decline in Arizona, although it may be increasing its range in north-central Arizona and western New Mexico. The species' overall status in the Southwest has not been determined. The elf owl was never a common or widespread species along the lower Colorado River. Surveys of riparian habitats in the lower Colorado River Valley in 1987 reported between 17 and 24 owls at ten different sites (CDFG, 1991). Population estimates in California for the early 1990s were 17 to 25 breeding pairs (CDFG, 1991; Rosenberg et al., 1991). Riparian habitat in the Grand Canyon may provide suitable breeding habitat for the elf owl; however, based on the available information, it is unknown whether elf owls occur. The riparian habitat along the Colorado River above Lake Mead may be utilized by elf owl and has the potential to be affected by the interim surplus criteria.

**Gilded Flicker** – The gilded flicker (*Colaptes chrysoides*) occurs along the lower Colorado River Valley in southern Arizona and southeastern California (Rosenberg et al., 1991). In California, the gilded flicker is an uncommon resident along the Colorado River north of Blythe (Garrett and Dunn, 1981, CDFG, 1991). During the breeding season, the gilded flicker is found in saguaro habitats, mature cottonwood-willow riparian forests, and occasionally mesquite habitats with tall snags (CDFG, 1991; Rosenberg et al., 1991). This species was historically widespread in riparian habitat all along the Colorado River Valley. Based on available information, it is not known whether this species occurs in the lower Grand Canyon, although suitable habitat is present in both the riparian and mesquite habitats.

**Southwestern Willow Flycatcher** – The Southwestern willow flycatcher (*Empidonax traillii extimus*) is a riparian obligate, neotropical migratory insectivore that breeds along rivers, streams, and other wetlands where dense willow, cottonwood, tamarisk, or other similarly structured riparian vegetation occurs (Service, 1995a; McKernan 1999; AGFD, 1997e). Populations of breeding Southwestern willow flycatchers have been recorded at the upper Lake Mead delta, the Virgin River delta, Mormon Mesa North, and the Lower Grand Canyon (AGFD, 1997e; Sogge et al., 1997). However, due to high lake levels, as discussed previously, the Lake Mead and Virgin River delta willow flycatcher habitat has been inundated. This change in reservoir elevation has permitted suitable willow riparian habitat to develop in the Colorado River corridor from Lake Mead up to approximately Separation Canyon (McKernan, 1999). The occurrence of this species and habitat below Lake Mead to the SIB is discussed in the BA for this proposed action (Reclamation, 2000).

The Grand Canyon population of Southwestern willow flycatcher is important from a scientific and management perspective because it is one of the longest continuously monitored populations in the southwest (Sogge et al., 1997). In support of this view, the USFWS designated river mile 39 downstream to river mile 71.5 as critical habitat for this species (USFWS, 1997a, 1997c). This habitat occurs in the upper Grand Canyon and will not be affected by the interim surplus criteria.

High lake levels (above 1192 feet) appear to be detrimental to Southwestern willow flycatcher nesting habitat at Lake Mead delta due to potential loss of suitable nest trees (Reclamation, March 1998). Lake levels below 1192 feet during the willow flycatcher breeding season (April through August) appear to allow for increased willow habitat establishment which would be beneficial to the species. From January 1978 until June 1990, Lake Mead elevations were above 1182 feet on a continuous basis. In June 1990, Lake Mead elevation declined to approximately 1182 feet and stayed below that elevation until the end of 1992 (Reclamation, 2000). If saturated soils are present in areas occupied by willow flycatcher, declines in lake levels during June have little to no effect on nesting. In contrast, when Lake Mead's elevation is high enough to inundate the delta, which typically occurs during June and July (Reclamation, 2000), willow flycatchers would not be affected because their territories and possibly nest sites would be established. Because suitable habitat utilized by Southwestern willow flycatcher may be affected by changes in Lake Mead water levels that would result from implementation of the interim surplus criteria, the species is considered in the environmental consequences section below. The interim surplus criteria are not expected to result in hydrologic changes below Hoover, Davis and Parker dams that would adversely affect the flycatcher.

**Yuma Clapper Rail** – The Yuma clapper rail (*Rallus longirostris yumanensis*), one of seven North American subspecies of clapper rails, occurs primarily in the lower Colorado River Valley in California, Arizona and Mexico. It is a fairly common summer resident from Topock Gorge south to Yuma in the United States, and at the Colorado River delta in Mexico. In the area under consideration, the Yuma clapper rail is associated with freshwater marshes with the highest densities of the subspecies occurring in mature stands of cattails and bulrush (Reclamation, August 1999). In recent years, individual clapper rails have been heard at Laughlin Bay and Las Vegas Wash in southern Nevada (NDOW, 1998), and individuals have been documented at the Virgin and Muddy rivers including the Virgin River floodplain between Littlefield, AZ and the Virgin River Delta, NV (McKernan, 1999), and at sites within the lower Grand Canyon (McKernan, 1999). The occurrence of the Yuma Clapper below Lake Mead to the SIB is discussed the BA for this proposed action (Reclamation, 2000). The marsh habitat utilized by Yuma clapper rail has the potential to be affected by the interim surplus criteria.

**Western Yellow-billed Cuckoo** – Historically, the western form of the yellow-billed cuckoo (*Coccyzus americanus*) was a fairly common breeding species throughout the river bottoms of the western United States and southern British Columbia (Gaines and Laymon, 1984). Due to the loss of riparian woodland habitat, the cuckoo has become an uncommon to rare summer resident in scattered locations throughout its former range. Western yellow-billed cuckoo have been documented in riparian habitat in the lower Grand Canyon and Virgin River above Lake Mead (McKernan, 1999) (Reclamation, 2000) as well as in habitat along the river corridor below Lake Mead and has the potential to be affected by the interim surplus criteria.

### 3.8.3.4 SPECIAL-STATUS FISH SPECIES

Described below are special-status fish species present within the area under consideration. Table 3.8-3 lists special-status fish species including common name, scientific name and status. Currently, the Service is supplementing existing recovery plans for the four endangered fish species included in this analysis.

Critical habitat has been designated for each of the federally listed fish species (Federal Register: March 21, 1994), and portions of this habitat exist within the area of potential effect (Reclamation, 2000).

**Table 3.8-3**
**Special-Status Fish Species Potentially Occurring Within the Area of Analysis**

| Common Name | Scientific Name | Status |
|---|---|---|
| Bonytail | *Gila elegans* | Federally Listed Endangered (critical habitat designated);<br>California Endangered;<br>Nevada State Protected |
| Colorado pikeminnow | *Ptychocheilus lucius* | Federally Listed Endangered (critical habitat designated);<br>California Endangered |
| Flannelmouth sucker | *Catostomus latipinnis* | Federal Species of Concern;<br>Arizona Wildlife Species of Concern;<br>Bureau of Land Management Nevada Special Status Species |
| Humpback chub | *Gila cypha* | Federally Listed Endangered (critical habitat designated) |
| Razorback sucker | *Xyrauchen texanus* | Federally Listed Endangered (critical habitat designated) |

**Bonytail** – Adult bonytail (*Gila elegans*) were once found throughout the big rivers and major tributaries of the Colorado River basin. Younger fish utilize the smaller streams and quiet areas. Bonytail prefer substrate which consists of clay, soft mud, or mud and sand, or occasionally rocks, gravel or rubble with little or no vegetation (Sigler and Miller, 1963; Wydoski, 1995). Adults range between eight and 17 inches in length and weigh just over one pound. The species can live for over 40 years. Spawning occurs in late spring to early summer usually over gravel bars with no nest being constructed. Gravid females can carryover 10,000 eggs each. Bonytail are carnivorous, feeding on insects, crustaceans, small fish, and snails; however, filamentous algae are often consumed (NPS, 1998).

The bonytail is now the rarest native fish within the Colorado River Basin (NPS, 1998). The decline in the number of bonytail are thought to be a result of changes in historical stream flow and water temperatures, blockage of migratory routes by dams and introduction of non-native fish species. At Lake Powell, present numbers are accounted for by fish older than 40 years of age; no recruitment has been demonstrated in recent years (NPS, 1998).

Bonytail are believed to be extirpated in the Colorado River from Glen Canyon Dam to Hoover Dam (McCall, 1979 and Reclamation, 1996a). Small populations may still exist in the Upper Basin, but there is much confusion in fish identification due to the similarity in physical appearance with roundtail chubs (Reclamation, 1996a). Five suspected bonytail were captured in Cataract Canyon between 1985 and 1988, with one caught in Lake Powell near Wahweap Marina (Maddux et al., 1993 and Reclamation, 1995).

Critical habitat for bonytail includes the Colorado River from Hoover Dam to Davis Dam, including Lake Mohave. It also includes the Colorado River from the northern boundary of Havasu National Wildlife Refuge to Parker Dam, including Lake Havasu. The largest remaining population of bonytail in the entire Colorado River Basin resides in Lake Mohave. There were at least nine augmentation stockings of bonytail into Lake Mohave between 1981 and 1991 (Reclamation, 1996a). Efforts are being undertaken to repatriate bonytail back to Lake Havasu from lakeside coves using young obtained from Dexter National Fish Hatchery (Reclamation, 1996a). The primary limiting factor for bonytail appears to be non-native fish predation of the early life stages (egg to subadult) (Reclamation, 1996a).

**Colorado pikeminnow** – The Colorado pikeminnow (*Ptychocheilus lucius*) is the largest member of the minnow family within North America and is endemic to the Colorado River system. It was, historically, the top predator fish in the Colorado River, but native populations are now restricted to the upper Colorado River Basin (Reclamation, 1996a). A portion of their current distribution includes the Colorado River from Palisades, Colorado, downstream to Lake Powell (NPS, 1998). Colorado pikeminnow have been captured in Lake Powell as recently as 1999 (Reclamation, file data). Designated critical habitat within the area of effect for the analysis is limited to the normal pool elevation of Lake Powell. Colorado pikeminnow are now considered extirpated from the entire Lower Basin; where they were once extremely abundant. The last known wild adults from the lower Colorado River were captured in the 1960s, and the last known specimens from the Gila River basin were collected in 1958 (Minckley, 1973). Colorado pikeminnow were taken from Lake Havasu in the 1970s. Populations in the upper basin are thought to be stable or increasing, with documented natural recruitment.

The species is adapted to large seasonal flow variations, high concentrations of silt, turbulence, periodically low food availability and naturally variable riverine subsystems. It is typically a big river fish where the current is strong and the water heavily silt laden. Colorado pikeminnow are migratory and can utilize anywhere from 100 to 200 miles of river to complete their life cycle. Spawning takes place from spring to late summer depending on water temperatures. Larva and juvenile pikeminnow can drift 60 to 150 miles from spawning beds into nursery areas where they mature to a size that mostly prevents predation (Maddux et al., 1993; Sigler and Miller, 1963).

**Flannelmouth sucker** – The flannelmouth sucker (*Catostomus latipinnis*) was historically found in medium to large rivers throughout the upper and lower Colorado River drainage (Joseph et al., 1977; AGFD, 1996a). Although the flannelmouth sucker is currently widely distributed in the upper Colorado River Basin (Holden and Stalnaker 1975a, b; McAda, et al., 1994), its occurrence in the lower Colorado River Basin has become more restricted. The species' range in the Upper Basin includes the main stem of the Colorado River, numerous tributaries that drain a large portion of Colorado and Utah, and the San Juan River drainage in New Mexico and Utah. In the Lower Basin, the flannelmouth sucker occurs only in localized areas of suitable habitat (Sublette et al., 1990). Populations in the Lower Basin occur in the Little Colorado River, Virgin River, Colorado River in Glen Canyon, Grand Canyon, and immediately below Davis Dam, and several small tributaries to the Colorado River above Lake Mead (AGFD, 1996a; Valdez and Carothers, 1998).

Flannelmouth suckers typically require medium to large flowing streams and react poorly to impounded habitats or habitats influenced by impoundments (Minckley, 1973), and the artificial thermal regime created by impoundments. Subadult flannelmouth suckers in the Grand Canyon use sheltered shoreline habitats, backwaters, and tributary inflows (Valdez and Ryel, 1995). Conversely, adults can be found in a variety of mainstem habitats, including: tributary mouths, vegetated shorelines, mid-channel cobble bars (Valdez and Ryel, 1995), eddies (Holden and Stalnaker, 1975a; and Valdez and Ryel, 1995) and riffles (Holden and Stalnaker, 1975a). Spawning can take place from spring to early summer and is often preceded by an upstream migration.

Since 1986, the AGFD has conducted yearly monitoring of flannelmouth sucker populations in the Colorado River from Lees Ferry downstream to Lake Mead. The Glen Canyon Monitoring and Research Center (1998) has funded monitoring and research activities for this species. The objective of this program is to provide the knowledge base required to implement ecosystem management strategies within an adaptive management framework.

**Humpback chub** – Endemic to the Colorado River, the humpback chub (*Gila cypha*) inhabits the canyon-bound sections of the Colorado, Green and Yampa rivers, with high fidelity for particular localized sites. Young are not known to widely disperse. The historical abundance and distribution of the fish is not well known. Designated critical habitat includes the Colorado River from Nautiloid Canyon to Granite Park in the Grand Canyon, and the lower eight miles of the Little Colorado River, including its confluence with the Colorado River. The largest population still extant is found in and near the Little Colorado River within the Grand Canyon (Maddux et al., 1993; Valdez and Ryel, 1995). This population uses the Little Colorado River for spawning and rearing. The possibility exists that humpback chub found in the Middle Granite Gorge and lower Grand Canyon may represent a separate population (Reclamation, 1996a).

Humpback chub becomes reproductively active between May and July depending on location and the hydrograph. Males become reproductively mature within three years. Spawning occurs during the highest spring flows when water temperatures approach 68°F (20°C) over cobble or gravel surfaces. Larvae tend to utilize silty bottom habitats. Later, humpback chub utilize a variety of habitats within a boulder strewn canyon environment (i.e., pools, riffles and eddies). They move between habitats dependent on life history needs and natural habitat change (NPS, 1998).

Young humpback chub feed mainly from the bottom eating small invertebrates and diatoms. Adults also feed mainly from the bottom but also feed on floating aquatic and terrestrial insects (SWCA, 1997; Valdez and Ryel, 1995; Wydoski, 1995).

**Razorback sucker** – The razorback sucker (*Xyrauchen texanus*) was formerly the most widespread and abundant of the big-river fishes in the Colorado River. In the lower basin, razorback sucker apparently began to decline shortly after impoundment of Lake Mead in 1935. Today the species occupies only a small portion of its historical range, and most occupied areas have very low numbers of fish. Critical habitat for the razorback sucker includes Lake Mead and Lake Mohave, and the river reach between them. It also includes the Colorado River and its 100-year floodplain from Parker Dam to Imperial Dam. Reclamation's BA includes a detailed discussion of this species occurrence and requirements (Reclamation, 2000).

In Lake Mead, the fish were abundant for many years after the reservoir filled, but declined during the 1960s and 1970s. The current population in Lake Mead is estimated to be less than 300 fish. The capture of a small number of juvenile adults since 1997 along with recent capture of larval razorback sucker in the spring of 2000 (Holden, Personal communication) indicates some successful recruitment is taking place. There are two populations of razorback sucker in Lake Mead in Las Vegas Bay and Echo Bay. A five-year study is underway to determine population size and movements of this fish and to determine why there is a small number of fish able to recruit, thus enabling a small number of razorback sucker to persist in Lake Mead.

The razorback sucker is a large fish, reaching over two feet in length and eight pounds in weight. Reproduction in the lower basin has been studied in Lake Mead and Lake Mohave. Spawning in Lake Mohave typically begins in January or February, while in Lake Mead it begins slightly later (Jonez and Sumner, 1954). Spawning typically runs 30 to 90 days at water temperatures ranging from 55°F to 70°F (13°C to 21°C). Spawning areas tend to be wave-washed, gravelly shorelines and shoals. Fish spawn in water from three to 20 feet in depth with the majority of fish in the five- to 10-foot range. Razorback suckers apparently spawn continuously throughout the spawning season, with females releasing only a portion of their gametes at each event. Spawning occurs both day and night on Lake Mohave (Reclamation, file data). Eggs hatch in five to 10 days depending on water temperature. Optimal hatching success is around 68°F (20°C); hatching does not occur at extremes of cold or hot (50°F or 86°F; 10 C to 30 C) (Marsh and Minckley, 1985). Larvae swim up within several days and begin feeding on plankton. Juvenile razorback suckers in lakeside rearing ponds hide during the day in dense aquatic vegetation and under brush and debris and in rock cavities (Reclamation, 1996a, 2000).

Most of the remnant populations of razorback sucker are found in Lake Mead and Lake Mohave (Reclamation, 2000). They are considered rare in the Grand Canyon and have been documented in Lake Powell as recently as 1999 (Reclamation, file data). Spawning success has been limited by the predation of eggs and young by non-native species. Currently, efforts are being made to introduce razorback sucker that have been raised in areas free of predators into Lake Mohave to help establish a larger population of breeding adults, and continued study of the persistent population in Lake Mead is planned (Reclamation, 2000).

## 3.8.4 ENVIRONMENTAL CONSEQUENCES

This section evaluates the potential effects on special-status species and their habitat that could occur as a result of implementation of the interim surplus criteria alternatives under consideration. This section is divided into three main special-status species categories: plants, wildlife and fish. For each category, the potential effects under baseline conditions are presented first, followed by a discussion of the alternatives as compared to baseline conditions.

### 3.8.4.1 EFFECTS ON SPECIAL-STATUS PLANT SPECIES

Only four plant species would potentially be affected by hydrological changes associated with the interim surplus criteria alternatives: Geyer's milkvetch, Grand Canyon evening primrose, Las Vegas bear poppy and sticky buckwheat.

#### 3.8.4.1.1 Baseline Conditions

Geyer's milkvetch, which occurs along the shoreline of Lake Mead, is mainly threatened by loss of habitat from inundation as a result of rising water levels at Lake

Mead, invasion of shoreline (beach) habitat by tamarisk and arrowweed, and possibly trampling and grazing by burros. Shoreline recreation does not currently appear to be a major threat to this species because the beaches where it occurs do not receive heavy recreational use. This species would be affected by variations in Lake Mead surface elevations if suitable habitat were inundated. Baseline conditions indicate a decreased potential over time for such inundation to occur. If lake levels decline, exposing sand dune habitat and sandy soils, the species could benefit. However, if these areas are colonized by tamarisk after being exposed, there would be no net benefit.

Grand Canyon evening primrose are found in beach habitat within the Grand Canyon. The beach habitat in the Grand Canyon is often invaded by riparian vegetation and is also utilized by recreationists, which results in adverse conditions for Grand Canyon evening primrose establishment. To the extent that beach habitat is altered by releases from Glen Canyon Dam, this species is covered under the Glen Canyon Dam ROD (1996) and Adaptive Management Program. Indirect effects to the habitat for this species may, however, result from fluctuations in Lake Mead pool elevations. Under baseline conditions, Lake Mead elevations are projected to decline over time. Reductions in Lake Mead elevations would likely result in an increase in exposed beach habitat in the lower Grand Canyon to Lake Mead that would potentially provide more suitable habitat for Grand Canyon evening primrose.

Las Vegas bear poppy occurs along the lower levels of the Lake Mead shoreline. As with the Geyer's milkvetch, this species would benefit from lower water levels at Lake Mead and would be adversely affected by any increases in water levels. Benefits of lower surface elevations would be negated if invasion of exposed areas by tamarisk or other weedy exotic plant species were to occur.

Sticky buckwheat is found primarily along the Overton Arm of Lake Mead with smaller, potentially significant populations occurring in the vicinity of Overton Beach, along the Virgin River Valley, and along the Muddy River. As with the other three special-status plant species discussed, the major threats to sticky buckwheat at Lake Mead are the loss of habitat from inundation as the result of rising water levels at Lake Mead, and the invasion of shoreline (beach) habitat by tamarisk and arrowweed. This species could potentially benefit from lower lake levels at Lake Mead provided the newly exposed habitat was not colonized by weedy exotic plant species.

#### 3.8.4.1.2 Effects of the Alternatives

Potential effects to special-status plant species under the each of the alternatives would be similar to baseline conditions. Each alternative would result in Lake Mead elevations that would vary from those under baseline conditions, with the Flood Control Alternative resulting in slightly higher reservoir elevations, and the Basin States, Six States, California and Shortage Protection alternatives having lower reservoir elevations as compared to baseline projections. (Section 3.3 discusses the modeling results concerning potential future reservoir elevation trends in detail.) The differences in potential future Lake Mead elevations under the alternatives as compared with baseline conditions are not expected to adversely affect the special-status plant species discussed above, as lower Lake Mead elevation trends may benefit these species.

### 3.8.4.2 EFFECTS ON SPECIAL-STATUS WILDLIFE SPECIES

Special-status wildlife species with potential to occur in the area under consideration are Arizona Bell's vireo, bald eagle, California black rail, Clark's grebe, Cooper's hawk, elf owl, gilded flicker, Southwestern willow flycatcher, Yuma clapper rail and western yellow-billed cuckoo.

Under baseline conditions and each of the alternatives, the water surface elevation projected for Lake Powell indicates a potential for slightly declining water levels during the first 15 years of the period of analysis. Figure 3.3-6 in Section 3.3 shows modeled Lake Powell elevations. The differences between the alternatives and baseline conditions would not affect any special-status wildlife species identified for this analysis and as a result, Lake Powell is not discussed further.

#### 3.8.4.2.1 Baseline Conditions

Water fluctuations of Lake Mead generally preclude development of shoreline riparian vegetation, with the exception of tributary inflow areas such as the Virgin River and Lake Mead deltas (Reclamation, 1999). Woody riparian vegetation (i.e., cottonwood and willow) become abundant from below Separation Canyon to the Lake Mead delta as lake levels declined following high runoff years of 1983-1986 (Reclamation, 1995). As the probability for declining reservoir levels increases over time under baseline projections (as shown on Figure 3.3-13 in Section 3.3), an increase in the amount of sediment exposed in the Lake Mead and Virgin River deltas would again create favorable conditions for establishment of woody riparian habitat. An increase in riparian habitat along the deltas would potentially benefit Arizona Bell's vireo, Cooper's hawk, elf owl, gilded flicker, western yellow-billed cuckoo and Southwestern willow flycatcher. The interim surplus criteria alternatives are not expected to impact these species in the river corridor below Hoover Dam to the SIB (Reclamation, 2000).

The increase in the probability for Lake Mead water levels to decline under baseline projections would also increase potential for sediment exposure that may create suitable conditions for marsh vegetation to develop and/or expand at the Lake Mead and Virgin River deltas, as well as along the Colorado, Virgin and Muddy rivers above Lake Mead. This would in turn increase the amount of preferred habitat for California black rail, Clark's grebe and Yuma clapper rail.

Riparian and marsh vegetation is typically located within the shallow water table zone near the lake shoreline. Although lowering lake levels has the potential to increase the amount of riparian and marsh vegetation because of increased sediment exposure, these habitat types would only become established if lake levels do not drop excessively. If the exposed sediment is too far above the water table, riparian and marsh habitat is not likely to become established.

#### 3.8.4.2.2 Effects of the Alternatives

Potential effects on special-status wildlife species would be similar to baseline conditions. Each alternative would result in Lake Mead elevations that would vary from those under baseline conditions, with the Flood Control Alternative resulting in slightly higher reservoir elevations, and the Basin States, Six States, California, and Shortage Protection alternatives having lower reservoir elevations as compared to baseline projections. (Section 3.3 discusses the modeling results concerning potential future reservoir elevation trends in detail.) Under each of the alternatives, vegetation associated with Lake Mead, including riparian and marsh habitat in the Virgin River and Lake Mead deltas, would experience changes similar to those described above under baseline conditions. Consequently, the potential for changes in special-status species' habitat associated with Lake Mead, and the Lake Mead and Virgin River deltas under the alternatives would be similar to those described for baseline conditions above.

### 3.8.4.3 EFFECTS ON SPECIAL-STATUS FISH SPECIES

Operations at Glen Canyon Dam and Hoover Dam include various programs designed to aid in the conservation and recovery of endangered native species in the lower Colorado River basin. These programs include Section 7 consultations under the ESA, the Glen Canyon Dam Operation AMP and ROD (1996), and the LCRMSCP. Reclamation is also a participant in the Upper Colorado and San Juan River Basin Recovery Implementation Programs for endangered fish in the upper Colorado River basin. Critical habitat for all four of the endangered fish species has been designated by the Service. Adverse modification of these habitats is prohibited under Section 7 of the ESA. These programs and protections will remain in effect under baseline conditions and each of the interim surplus criteria alternatives. As discussed, conditions are not favorable for endangered fish. Future baseline conditions and each of the interim surplus criteria are expected to increase, to varying degrees, the potential for reduced reservoir surface elevations. The following discuss effects of the alternatives on each of the special-status fish species.

### 3.8.4.3.1 Baseline Conditions

**Bonytail** - Under baseline conditions, it is anticipated that bonytail in the Colorado River Basin and their designated critical habitat would continue to be protected under the ESA. Reclamation has consulted with the Service under Section 7 of the ESA on the operation of Glen Canyon and Hoover dams. The resulting biological opinions will remain in effect. Reservoir operations remain within historical ranges, and efforts to protect, recover, and monitor the species status would continue.

The main effort to protect and conserve bonytail in the Lower Basin is the reintroduction of fingerling bonytail from the Dexter National Fish Hatchery, New Mexico that have been reared in predator-free ponds into Lake Mohave by the NFWG. The primary limiting factor for bonytail under existing habitat conditions is predation of early life stages by non-native species. This program is designed to address predation and maintain genetic stocks of bonytail. The main efforts to protect and conserve bonytail in the Upper Basin are conducted through the Upper Colorado Recovery Implementation Program (UC-RIP). This program is designed to recover the bonytail in the Upper Basin by 2010.

**Colorado pikeminnow** - Under baseline conditions, it is anticipated that Colorado pikeminnow would continue to be restricted to the Upper Basin. Colorado pikeminnow and their designated critical habitat would continue to be protected under the ESA. The Colorado pikeminnow is extirpated from all areas considered in this analysis except for Lake Powell. The ability of the Colorado pikeminnow to successfully reproduce in Lake Powell has not been confirmed. Successful spawning occurs in riverine habitats above Lake Powell, and larvae then drift downstream to rear in sheltered environments. Survival of larvae that drift into Lake Powell is limited by predation by non-native fish. As development of water continues to occur in the upper basin, lower lake elevations are expected to occur. This will increase the amount of sheltered riverine habitat and indirectly benefit the survival of some larvae by preventing them from drifting into open water areas of the reservoir where the risk of predation is greater. The main efforts to protect and conserve Colorado pikeminnow in the Upper Basin are conducted through the UC-RIP, plus the San Juan River Basin Recovery Implementation Program (SJ-RIP). This program is designed to recover the pikeminnow in the Upper Basin by 2010.

**Flannelmouth sucker** - Under baseline conditions, it is anticipated that flannelmouth sucker populations in the project area would continue to be found in riverine habitats and tributaries. The species is not well adapted to reservoir habitats and are seldom found there. The low survival of eggs and larvae in the reservoirs may be attributed to impacts from cold water temperatures or predation by non-native species. These conditions would continue to limit the reproductive success of flannelmouth sucker in the reservoirs. For flannelmouth sucker that spawn in rivers upstream of Lake Mead and Lake Powell or other inflow areas, survival of larvae that drift into the reservoirs is limited by cold water temperatures and predation of non-native fish. Lower lake elevations may increase the amount of sheltered riverine habitat and indirectly benefit the survival of some larvae by preventing them from drifting into open water areas of the reservoir where the risk of predation is greater. Efforts to improve habitat conditions under the UC-RIP, SJ-RIP, Glen Canyon Dam AMP and the Lower Colorado MSCP will benefit the flannelmouth sucker.

**Humpback chub** - Under baseline conditions, it is anticipated that humpback chub populations would continue to be restricted to riverine and tributary habitats in the Colorado River in the Grand Canyon. The humpback chub and its designated critical habitat would continue to be protected under the ESA, the 1996 ROD, flow regimes and other activities as prescribed under the 1995 biological opinion and the Glen Canyon Dam AMP. In addition to the populations of the Grand Canyon, there are five stable populations in the Upper Basin. The UC-RIP and SJ-RIP are making progress toward recovery of the species. The humpback chub is considered extirpated from all other areas within the lower Colorado River Basin.

**Razorback sucker** - Under baseline conditions, it is anticipated that razorback sucker populations in the Lower Basin would continue to be limited primarily to Lake Mead and Lake Mohave and designated critical habitat would continue to be protected under the ESA. Spawning success has been limited by predation of eggs and larvae by non-native fish. Efforts are currently being made by the NFWG to supplement adult breeding populations of razorback suckers by stocking lakes and the river with young reared in predator free ponds. Operations at Lake Mohave are conducted in an effort to conserve and protect razorback sucker by controlling the amount of lake fluctuation during the spawning season. A five-year study of the remnant razorback sucker population in Lake Mead is scheduled to be completed by 2002. These practices are expected to continue under baseline conditions and all the interim surplus criteria alternatives.

#### 3.8.4.3.2 Effects of the Alternatives

Potential effects on the five special-status fish species discussed above would be similar to baseline conditions. Each alternative would result in Lake Powell and Lake Mead surface elevations that would vary from those under baseline conditions, with the Flood Control Alternative resulting in slightly higher reservoir elevations, and the Basin States, Six States, California and Shortage Protection alternatives having lower reservoir elevations as compared to baseline projections. (Section 3.3 discusses the modeling results concerning potential future reservoir elevation trends in detail.) Efforts toward protection and recovery of these species would continue under each of the alternatives in the same manner as describe above for baseline conditions. Potential changes in BHBF and low steady summer flow frequencies are discussed in Section 3.6 of this FEIS, and Reclamation has determined that these effects would not be likely to adversely affect special-status fish species.

# 3.9 RECREATION

## 3.9.1 INTRODUCTION

The Colorado River, Lake Mead and Lake Powell provide water-based recreation opportunities that are of local, regional and national significance, as well as international interest.

This recreation analysis addresses five specific recreation-related issues associated with potential effects that could result from implementation of the interim surplus criteria alternatives considered in this document. The issues addressed are potential effects to:

- Reservoir marinas and boat launching and shoreline access for Lake Powell and Lake Mead;
- Lake Mead and Lake Powell boating and navigation;
- River and whitewater boating;
- Sport fishing in Lake Powell, Lake Mead and the Colorado River below Hoover Dam; and
- Recreational facilities operational costs.

The interim surplus alternatives would not change the current and projected operations of Lakes Mohave and Havasu and thus would not affect recreation on those reservoirs.

## 3.9.2 RESERVOIR MARINAS, BOAT LAUNCHING AND SHORELINE ACCESS

This section considers potential effects of the interim surplus criteria alternatives on Lake Powell and Lake Mead marinas, boat launching facilities and other important shoreline access areas.

### 3.9.2.1 METHODOLOGY

Information in this section was compiled after review of available published and unpublished sources, and through personal communication with Reclamation, NPS and resource specialists. Thorough review of existing literature on the Colorado River provided information on reservoir recreation use for both Lake Powell and Lake Mead. Where available, the number of facilities at each marina, boat launching ramp and shoreline access area are included.

From the information compiled, representative threshold pool elevations were selected for facilities, at or below which certain facilities may be rendered inoperable or relocation of facilities could be required to maintain their operation. These thresholds were chosen based on either information provided in studies, communications with NPS personnel, or from comments received regarding the DEIS. Discussions of the probabilities of these thresholds occurring is detailed in the Environmental Consequences Section (Section 3.9.2.3). The probability of reservoir elevations occurring below these levels under baseline conditions and the action alternatives was identified using river system modeling as described in Section 3.3.

Data generated from the river system model include the probability (represented graphically in the Environmental Consequences section) that the water level related to each alternative would be above the specified "threshold" pool elevations for each year during the period of analysis. The graphs indicate the general trend of elevation probabilities and present the incremental differences in probabilities for baseline conditions and each of the alternatives.

### 3.9.2.2 AFFECTED ENVIRONMENT

Recreational boating on Lake Mead and Lake Powell is dependent upon access to the water via shoreline facilities such as marinas, docks and launch ramps. Fluctuation in water levels is a normal aspect of reservoir operations, and facilities are designed and operated to accommodate it. However, decreased pool elevations or increased variations or rates in pool elevation fluctuation could result in increased operation costs, temporary closures or possibly permanent closures.

Reservoir pool elevations at Lake Powell and Lake Mead depend on annual inflow from the Colorado River upstream, and outflow from the respective dam to the Colorado River downstream for water deliveries. Operation of the Colorado River generally results in the highest pool elevations in Lake Powell in mid-summer and in Lake Mead, early winter. In general, pool levels in Lake Powell and Lake Mead tend to fluctuate on an annual cycle rather than on a monthly or seasonal cycle Lake Powell historical pool fluctuations have normally ranged from 20 to 25 feet per year (Combrinks and Collins, 1992). Since operation of Glen Canyon Dam began in 1966, Lake Mead pool fluctuation has normally ranged from 5 to 25 feet per year.

#### 3.9.2.2.1 Lake Powell Recreation Resources

Lake Powell is located in the Glen Canyon National Recreation Area (GCNRA) in southern Utah and northern Arizona. Typical recreation activities that occur at Lake Powell include swimming and sunbathing, power boating, fishing, off-beach activities associated with boat trips (such as hiking and exploring ruins), house boating, personal water craft use, canoeing, kayaking, sailing, and other activities (USBR, 1995b). A carrying capacity study (NPS, 1991) provided information on the potential limits of boater use on Lake Powell. The study also showed that the average length of stay at the GCNRA is 4.5 days.

Visitation numbers for the entire GCNRA between 1990 and 1999 are provided in Table 3.9-1. The data indicate that there are seasonal variability in recreation use. The majority of use occurs in the summer months of June, July and August. The visitation numbers shown for 1995 through 1999 are considerably lower than visitation between 1990 and 1994 due to changes in NPS methods for calculating visitation. However, the seasonal pattern of visitation does not change; use remains highest in summer months. The majority of visitors to the GCNRA travel either less than 30 miles to visit (29.1 percent) or travel 121 to 240 miles (28.9 percent). This indicates that the area is used predominantly by local and regional visitors.

**Table 3.9-1**
**Glen Canyon National Recreation Area Visitation**

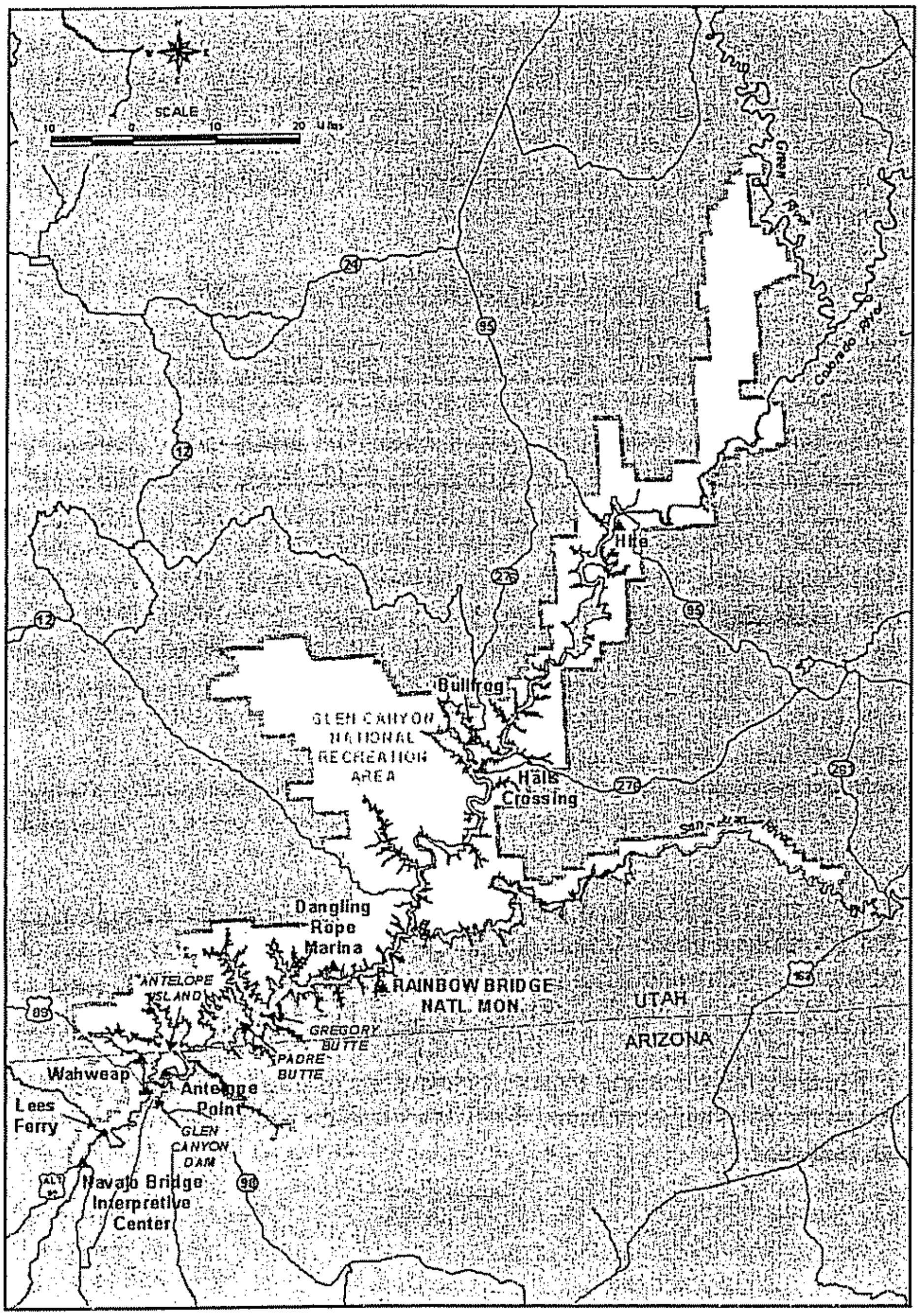
| Year | Jan | Feb | March | April | May | June | July | August | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 77.617 | 109,042 | 135.039 | 253,638 | 289,993 | 501,288 | 467.981 | 483,023 | 350,026 | 227,061 | 129,691 | 78.750 | 3,103.129 |
| 1991 | 81,875 | 97.120 | 118,182 | 199,462 | 346.764 | 451.674 | 503.752 | 568,030 | 396,785 | 247,982 | 120,822 | 78,442 | 3.210,890 |
| 1992 | 83,044 | 114,889 | 139,787 | 246,993 | 346,727 | 525,610 | 572,869 | 659.809 | 478,032 | 245,565 | 122,386 | 82.847 | 3,620.558 |
| 1993 | 60.927 | 83.903 | 123.836 | 201.141 | 372.425 | 526.202 | 624.549 | 644,534 | 530.550 | 259,119 | 111,607 | 76,031 | 3.470,194 |
| 1994 | 69,663 | 120,307 | 174,272 | 264,265 | 364,826 | 576,355 | 665,583 | 439.177 | 321,961 | 212,729 | 99.097 | 63,607 | 3.371.842 |
| 1995* | 35.814 | 66.553 | 88.414 | 151,369 | 196,905 | 410.610 | 435,840 | 461,431 | 285.118 | 192.597 | 94,508 | 50.362 | 2,469,521 |
| 1996 | 41,303 | 50,553 | 96,296 | 209.243 | 231.655 | 419.288 | 447.417 | 442,180 | 268.266 | 187,949 | 89,670 | 48,269 | 2.532.087 |
| 1997 | 49,954 | 54,401 | 115.523 | 157,249 | 245,000 | 288,742 | 420,927 | 437.846 | 266,992 | 187,467 | 85,595 | 48.507 | 2.458.203 |
| 1998 | 39,241 | 55.538 | 89.971 | 171.234 | 267.509 | 389.167 | 445,423 | 398.776 | 285,105 | 197.673 | 77,247 | 50,315 | 2.467.199 |
| 1999 | 44,755 | 51,657 | 118,141 | 155.831 | 261.931 | 426.744 | 515.641 | 441.791 | 305.006 | 200.457 | 89,799 | 55,503 | 2,667.249 |

Source: Based on NPS data

* NPS methods for calculating visitation numbers changed in 1995 This resulted in significant reductions in visitation numbers compared to prior years.

Recreation boating is the largest type of boating activity on Lake Powell, with an estimated 1.5 million boater nights per year in 1988. Although use at some of the major marinas, such as Wahweap, Hall's Crossing and Bullfrog, decreased during a low water period in 1989, the total number of boats on Lake Powell was reported to have increased 14.5 percent by July 31, 1989, compared to the same period in 1988 (USBR, 1995b). Specific facilities and reservoir elevations important to their operation are discussed in the following sections. Map 3.9-1 depicts Lake Powell and the locations of shoreline facilities.

**Map 3.9-1**
**Lake Powell and Associated Shoreline Recreation Facilities**



### 3.9.2.2.2 Shoreline Public Use Facilities

Public use facilities at Lake Powell that include water-based recreation activities are Wahweap, Dangling Rope Marina, Halls Crossing, Bullfrog, Hite, and Antelope Point. The GCNRA Proposed General Management Plan (NPS, 1979) describes the estimated capacity and development at these areas; these estimates are based on general concepts only and further detailed planning was proposed to begin after the plan's acceptance in 1979. Table 3.9-2 summarizes the activities at each of the sites. If the actual number of improvements (boat slips, mooring buoys, houseboats, etc.) at a facility are known, it is listed in Table 3.9-2; otherwise, the presence of an improvement is indicated with a bullet (•). If an improvement does not exist, it is denoted with "N/A." Below is a description of the shoreline public use facilities at Lake Powell.

Wahweap – The facilities at Wahweap are the closest to Glen Canyon Dam, located off Interstate 89 at the mouth of Wahweap Bay. According to a study that addressed fluctuating lake levels and recreation use, the Stateline Launching Ramp at Wahweap became inoperable in 1989 when the lake elevation decreased to below 3677 feet msl (Combrink and Collins 1992). In 1993, NPS extended the Wahweap and Stateline boat ramps down to an operable level of 3612 feet msl (Henderson, 2000).

Dangling Rope Marina – The facilities at Dangling Rope Marina were proposed to replace the facilities at Rainbow Marina in Forbidding Canyon. All the facilities float, and they are only accessible by boat (NPS, 1979). In addition to the facilities, tour boats depart from Dangling Rope Marina for visits to Rainbow Bridge National Monument during the recreation season (NPS, 1993). There are no known reservoir surface elevations that would impair operation of this facility.

Halls Crossing – The facilities at Halls Crossing are located off Utah Highway 276 on the east shore of Lake Powell, across the bay from Bullfrog Marina. According to a study that addressed fluctuating lake levels and recreation use, the Halls Crossing Ferry Ramp became inoperable in 1989 when the lake elevation decreased to below 3675 feet msl (Combrink and Collins, 1992). In 1993, NPS extended the boat ramp down to an operable level of 3612 feet msl (Henderson, 2000).

Bullfrog – The facilities at Bullfrog are located midway up Bullfrog Bay, off of Utah Highway 276 and across the bay from Halls Crossing. According to a study that addressed fluctuating lake levels and recreation use, the Bullfrog Ferry Ramp became inoperable in 1989 when the lake elevation decreased to below 3675 feet msl. In addition, the Bullfrog Utility Service became inaccessible when the lake elevation decreased to below 3670 feet msl (road access was also unavailable at the slips) (Combrink and Collins, 1992). In 1993, NPS extended the boat ramp down to an operable level of 3612 feet msl (Henderson, 2000).

**Table 3.9-2**
**Lake Powell Shoreline Public Use Facilities**

| Facility | Wahweap | Dangling Rope Marina | Halls Crossing | Bullfrog | Hite | Antelope Point * |
|---|---|---|---|---|---|---|
| Lodging (rooms) | 375 | N/A | 20 | 56 | 5 | 200-225 |
| Restaurant/Snack Bar | 2/1 | N/A/1 | •/1 | 1/1 | N/A | • |
| Tour boats | 9 | N/A | N/A | 1 | N/A | 2 |
| Boat slips | 870 | N/A | 165 | 254 | 6 | 250-300 |
| Mooring buoys | 180 | N/A | 141 | 220 | 54 | N/A |
| Rental houseboats | 175 | N/A | 89 | 112 | 21 | 60 |
| Rental small boats | 150 | N/A | 44 | 50 | 27 | 60 |
| Dry storage | 450 | N/A | 230 | 750 | 109 | • |
| RV park (spaces) | 120 | N/A | 32 | 24 | N/A | 150 |
| Marina campstore | 1 | 1 | 1 | 1 | N/A | 1 |
| Store | • | • | 1 | 1 | 1 | 1 |
| Boat repair | • | • | • | • | N/A | N/A |
| Service station | • | • | gas | • | gas | • |
| Parking (spaces) | 2,500 | N/A | 300 | 1,575 | 150 | 220 |
| Campground (sites) | 215 | N/A | 64 | 100 | 6 | • |
| Picnic (sites) | 124 | N/A | 20 | 50 | N/A | N/A |
| Day use beaches/trails | N/A | N/A | N/A | N/A | N/A | • |
| Launching ramps | 2 | N/A | 1 | 1 | 1 | 1 |
| Airstrip | N/A | N/A | N/A | 3,500-foot, paved | 2,100-foot, paved | N/A |
| Visitor center, cultural center | • | N/A | N/A | N/A | N/A | • |
| Ranger station | • | N/A | • | • | N/A | • |
| Employee housing | • | • | • | N/A | • | • |
| Concessionaire quarters | 80 | N/A | 30 | 40 | 10 | N/A |
| Dorm units | 119 | 6 | 24 | 96 | 0 | N/A |
| Capacity (use per day) | 7,800-10,100 | 2,400-3,100 | 3,400-4,400 | 7,900-10,300 | 2,500-3,300 | N/A |

Source: NPS 1979. Proposed General Management Plan and personal communication, Norm Henderson, NPS, 2000.

• indicates presence of an improvement.

N/A not applicable – indicates no improvement

* Facilities shown are proposed. Existing facilities include an entrance station, gravel parking area, two permanent toilets, and a boat ramp. The Navajo Nation and NPS are in the process of developing the site.

Hite – The facilities at Hite are located off of Utah Highway 95. According to a study that addressed fluctuating lake levels and recreation use, the Hite Launching Ramp became inoperable in 1989 when the lake elevation decreased to below 3677 feet msl (Combrink and Collins 1992). In 1993 NPS extended the boat ramp down to an operable level of 3612 feet msl. However, the ramp area is known to be useable down to 3630 feet msl (Henderson, 2000).

Antelope Point – The facilities at Antelope Point are located off of Arizona Highway 98 on the southern side of Lake Powell. Development of Antelope Point only began recently, and data on visitation has not been collected on a formal basis. Existing facilities at the site consist of an entrance station where fees are collected, two permanent toilets, a large gravel parking area that can accommodate 220 vehicles, and a public boat ramp. The Navajo Nation, in conjunction with NPS, has plans to develop the site as a resort destination, and is in the process of selecting a master developer for the project. Facilities proposed for the site in the Development Concept Plan are listed in Table 3.9-2, above.

The existing boat ramp at Antelope Point currently extends down to 3677 feet msl. NPS provided Reclamation with construction drawings for extending the boat ramp down to 3620 feet msl as water elevation declines. The extended boat ramp would allow houseboats and other watercraft to launch down to elevations around 3625 feet msl, assuming about 5 feet of free board (Bishop, Personal Communication, 2000). NPS also provided Reclamation with a preliminary Antelope Point Marina layout drawing for reservoir elevation of 3600 feet msl, but it has not been established that a marina would be operable at this level.

Rainbow Bridge National Monument – The Rainbow Bridge National Monument is located on the south shore of Lake Powell and is bounded on three sides by the Navajo Reservation near the Utah/Arizona border. The facilities at the monument include courtesy docks, restrooms, a floating walkway, and a floating interpretive platform. Trails from the dock lead to viewing areas. One viewing area is used when Lake Powell is below the full-pool elevation of 3700 feet msl, and the other is used when the reservoir is at full-pool elevation. The docks and trail system are designed to accommodate lake level fluctuations allowed in the operation of Glen Canyon Dam and powerplants (from 3490 feet msl to 3700 feet msl) (NPS, 1993). If the lake levels fall below 3650 feet msl, the dock facilities would be moved and the old land trail through Bridge Canyon (submerged at full pool) would be hardened and used for access. The floating walkway and interpretive platforms would be removed and stored. The courtesy docks would be connected to the land trail with a short walkway (NPS, 1990). However, large quantities of silt that have been deposited where Bridge Creek flows into Lake Powell could create access problems at low water surface elevations. The large silt flats are difficult to cross with floating walkways; special construction techniques may be required to bridge these areas. At some lake elevations, it may be infeasible to maintain water access to the monument (NPS, 1993); however, the specific elevation is not known.

When Lake Powell is operated below 3700 feet msl, some of the Rainbow Bridge National Monument is within a high hazard flash flood area. The 100- and 500-year flood elevations in Bridge Creek are estimated to be 7.5 feet and 10 feet above the creek channel, respectively. For the area well upstream of Lake Powell, the trail follows the creek and is above both the 100- and 500-year floodplains. However, the trail route in the transition zone between the reservoir and creek, along the lake's edge, could be subject to water surface elevation increase, surface turbulence, and significant velocities, depending on the lake elevation at the time of flooding and the magnitude of the flood. For the lake itself, there would be little or no discernable water surface increase and the turbulence would be limited. When Lake Powell is at full operating pool, flash flood areas are well upstream of the reservoir, in the Bridge Creek Canyon drainage outside the monument.

The General Management Plan for Rainbow Bridge includes a Flash Flood Mitigation Plan. In the event of combined low pool elevations and flash flood conditions, there are four components of the mitigation plan that would be put in place. These components include: 1) a wayside exhibit with information to inform visitors of possible flash flood hazards; 2) additional signage in the flood hazard zones to alert visitors where to move in case of a flood; 3) identification of evacuation and emergency measures, including chain of command responsibilities, emergency supply locations, and support facilities; and 4) installation of a warning system that would alert visitors to evacuate.

Prior to the construction of Glen Canyon Dam, access to the area was primarily by foot. Since the creation of Lake Powell, access is now primarily by water, although the area is also accessible by trails through Navajo Mountain. Access to the monument is restricted during the recreation season in accordance with the monument's carrying capacity of 200 people at one time. In addition, access is limited daily during certain times of the day. Boat tours to the monument are allowed during the busier time of the day and originate at Dangling Rock Marina. All tours have an NPS interpreter on board to convey the monument's significance. Access during quieter times of the day is limited to five to eight private boats. During the off-season, access to the monument is unrestricted except that boat tours are managed to ensure that only one tour boat at a time is present at the monument (NPS, 1993).

#### 3.9.2.2.2.1 Threshold Elevations

From the information presented above on reservoir pool elevations, three elevations, 3677 feet msl, 3626 feet msl and 3612 feet msl, were identified as representative threshold elevations below which shoreline facilities at Lake Powell could be affected.

The existing boat ramp at Antelope Point extends down to elevation 3677 feet msl. This elevation is identified as one of the threshold elevations for the analysis of marinas and boat ramps at Lake Powell. As discussed above, the extended boat ramp would be operable down to 3625 feet msl The elevation of 3626 feet msl is discussed in the boating navigation and safety section (Section 3.9.3.3.1) and is considered to be representative of the threshold elevation for the extended boat ramp. Since the minimum reservoir elevation at which the Antelope Point Marina would be operable has not yet been established, the threshold elevations of 3626 feet msl (discussed above) and 3612 feet msl (discussed below) are assumed to apply to a future marina at Antelope Point.

As discussed above, the boat ramps at Wahweap, Halls Crossing, Bullfrog, and Hite are designed to operate down to 3612 feet msl. It is not known what adjustments and capital improvement costs would be required if elevations were to decline to below 3612 feet msl. As such, 3612 feet msl is used in this analysis as the lower threshold elevation for marinas and boat ramps at Lake Powell.

The threshold elevations of 3677 feet msl, 3626 feet msl and 3612 feet msl are used to evaluate baseline conditions and the effects of interim surplus criteria alternatives on shoreline facilities at Lake Powell in the Environmental Consequences section (Section 3.9.2.3.1). The threshold elevation of 3626 feet msl is evaluated in Section 3.9.3.3.1.

#### 3.9.2.2.3 Lake Mead Recreation Resources

Lake Mead, the reservoir created by the construction of Hoover Dam, is located in the Lake Mead National Recreation Area (LMNRA) in southern Nevada and northern Arizona. The LMNRA contains 1.5 million acres and encompasses the 100-mile-long Lake Mead, 67-mile-long Lake Mohave, the surrounding desert, and the isolated Shivwits Plateau in Arizona. At a full pool elevation of approximately 1210 feet msl, Lake Mead's surface area is 153,235 acres, the storage capacity is 25.9 maf and there are 695 miles of shoreline (USBR, 1996b). Lake Mead is the largest man-made lake in the Western Hemisphere.

LMNRA receives approximately ten million visitors annually. Typical water-based recreation activities that occur on Lake Mead include: swimming, boating, houseboating, fishing, sailboarding, paddlecraft use, scuba diving (USBR, 1996b). On average, the majority of boats are personal watercraft. There may be as many as 6000 boats combined on Lake Mead and Lake Mohave during a peak recreation use weekend. At Boulder Beach, which is located near the urbanized area of Las Vegas and surrounding communities, the personal watercraft percentage may be as high as 50 percent.

#### 3.9.2.2.4 Shoreline Public Use Facilities at Lake Mead

Six marinas at Lake Mead provide boat launching facilities as well as slips and storage, fuel and boat launches. In addition, there are three boat ramps without associated marinas and one site without a boat ramp. The marinas include Boulder Beach, Las Vegas Bay, Calville Bay, Echo Bay, Overton Beach and Temple Bar. The boat ramps are located at Hemenway, Government Wash and South Cove Pearce Ferry has no boat ramp and is used as a take out by private and commercial boaters that kayak and raft the Colorado River into Lake Mead. Facilities at the six marinas are summarized in Table 3.9-3, and all of the sites are described below. If the actual number of improvements (boat slips, etc.) at the facility is known, it is included in the table; otherwise, the presence of an improvement is indicated with a bullet (•). If there are no facilities at a location, this is indicated with an "N/A" for "not applicable." Map 3.9-2 shows the locations of both developed and undeveloped sites on Lake Mead.

**Table 3.9-3**
**Lake Mead Marina Public Use Facilities**

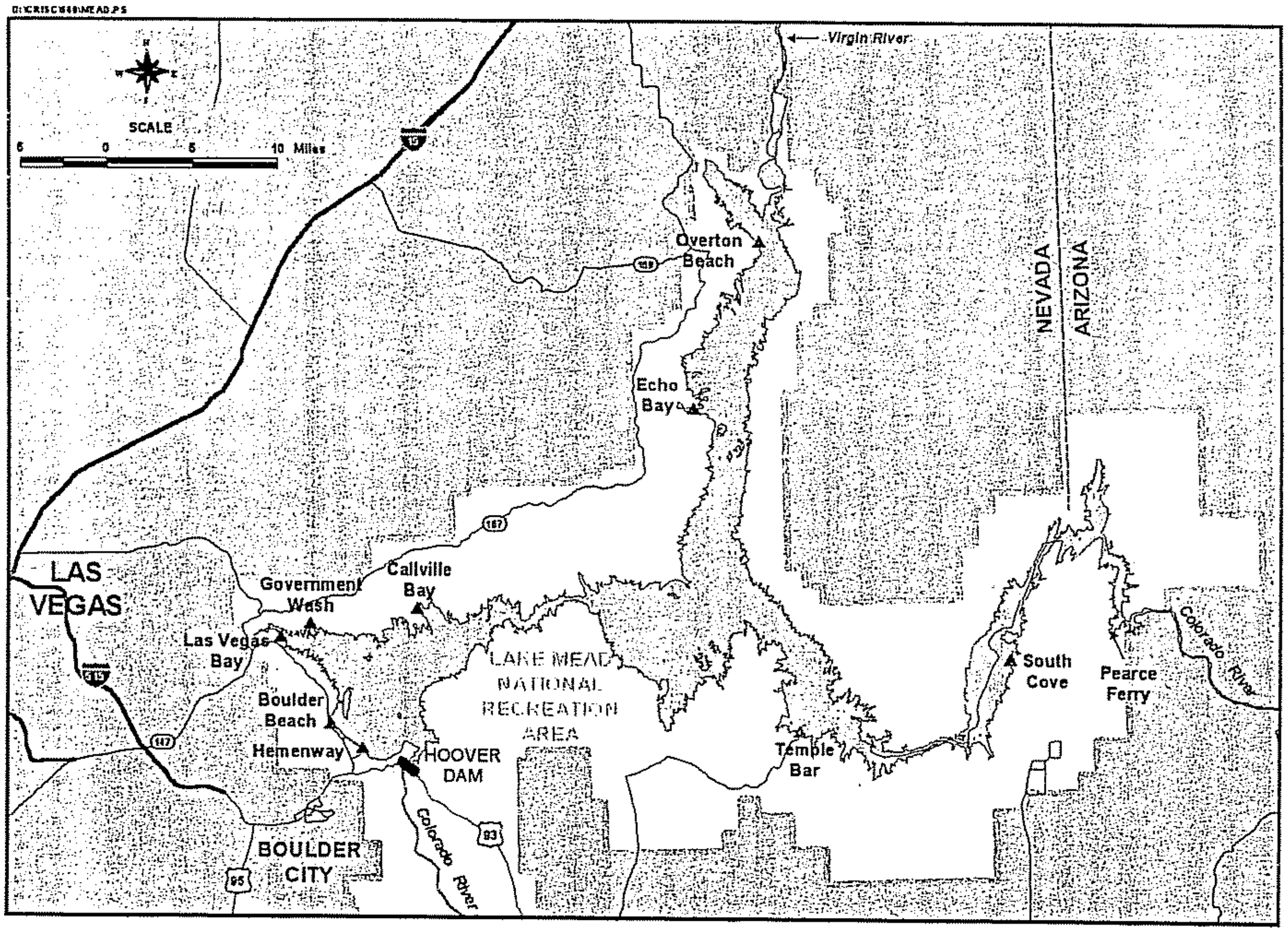
| Facility | Boulder Beach/ Lake Mead Marina | Las Vegas Bay | Calville Bay | Echo Bay | Overton Beach | Temple Bar |
|---|---|---|---|---|---|---|
| Lodging | • | N/A | N/A | • | N/A | • |
| Restaurant | • | • | • | • | • | • |
| Tour boats | • | N/A | N/A | N/A | N/A | N/A |
| Marina (boat slips) | 750 | • | 650 | 320 | • | • |
| Mooring buoys | N/A | N/A | N/A | N/A | N/A | N/A |
| Rental houseboats | N/A | N/A | • | • | N/A | N/A |
| Rental small boats | • | N/A | N/A | • | N/A | • |
| Dry storage | • | • | • | • | • | • |
| RV Park (spaces) | N/A | N/A | N/A | 58 | N/A | 7 |
| Trailer village | • | N/A | • | 69 | • | 111 |
| Trailer sewage dump | • | N/A | • | • | • | • |
| Grocery/gift store | • | • | • | • | • | • |
| Gasoline/Propane | • | N/A | • | • | • | • |
| Boat sewage dump | • | • | • | • | • | • |
| Parking (spaces) | N/A | N/A | N/A | N/A | N/A | N/A |
| Campground (sites) | 154 | 89 | 80 | 166 | N/A | 153 |
| Picnic (sites) | • | • | • | N/A | N/A | N/A |
| Showers | • | N/A | • | • | • | • |
| Launching ramps | • | • | • | • | • | • |
| Airstrip | N/A | N/A | N/A | • | N/A | • |
| Ranger station | • | • | • | • | • | • |
| Self-service laundry | • | N/A | • | • | • | • |
| Capacity (use per day) | N/A | N/A | N/A | N/A | N/A | N/A |

Source: NPS. 1995

• indicates presence of an improvement

N/A not applicable – indicates no improvement

**Map 3.9-2**
**Lake Mead and Associated Shoreline Recreation Facilities**



Recreation boating is very popular at Lake Mead, and the shoreline public use facilities are associated with boating use. Most of the facilities shown in the Table 3.9-3 were designed to operate at full pool. However, NPS has determined costs associated with adjusting facilities based on lowered lake elevations. These facilities are out of their normal operating range at pool elevations of 1180 feet msl, requiring sizable capital expenditures to restore them to working order. In addition, there are additional costs associated with any 20-foot drop below this level.

Hemenway – The boat ramp facility at Hemenway is the closest to Hoover Dam and is located off Nevada Highway 166. There is one courtesy dock and a parking area (Henderson, 2000). In addition, campgrounds and a group campground are located at Hemenway. The group campground is for self-contained vehicles, such as trailers and motor homes. There are no restrooms or tables.

Boulder Beach – The facilities at Boulder Beach are located off of Lakeshore Scenic Drive, just off of Nevada Highway 167 outside of Boulder City, Nevada, and include restrooms, tables and grills. There is also a group campground at Boulder Beach for tent camping only with limited vehicle parking.

Las Vegas Bay – The facilities at Las Vegas Bay are located off Lakeshore Scenic Drive, just off Lake Mead Drive (Nevada Highway 167). According to a marina worker, when the lake elevation drops below 1190 feet msl, the boat ramps and floats have to be readjusted.

Government Wash – The boat ramp facility at Government Wash is located off Nevada Highway 167. There is one courtesy dock and a parking area (Henderson, 2000).

Calville Bay – The facilities at Calville Bay are located off Nevada Highway 167 on the north shore of Lake Mead, midway up Calville Bay.

Echo Bay – The facilities at Echo Bay are located off Nevada Highway 167, midway up Overton Arm.

Overton Beach – The facilities at Overton Beach are located off Nevada Highway 169, near the top of Overton Arm.

South Cove – The boat launching facilities at South Cove are located off Aztec Wash, which is off Interstate 93 in Arizona. There is one courtesy dock, picnic facilities, and unpaved parking (Henderson, 2000). In addition, there is an airstrip approximately four miles from the facilities at South Cove (Henderson, 2000).

Temple Bar – The facilities at Temple Bar are located on the south shore of Lake Mead at the end of an unnamed road off Interstate 93 in Arizona.

Pearce Ferry - This area is located near Aztec Wash, which is off Interstate 93 in Arizona at the eastern end of the LMNRA. The area is a large, gravel wash with a gentle slope down to the water. Vehicles are driven down to the water's edge to load rafts and other small boats. There is parking and a year-round portable toilet, and primitive camping is allowed. There are no ramps, docks or other developed facilities at the site.

The Hualapai River Runners are one of the commercial guide services that use Pearce Ferry as a take out. The River Runners conduct guided whitewater trips that put in at Diamond Creek, and float trips that put in at Quartermaster Canyon. All of these trips take out at Pearce Ferry.

Comments from the Hualapai Tribe on the Draft EIS identified a Lake Mead pool elevation of 1183 feet msl as a threshold elevation for accessing the Pearce Ferry takeout. At this elevation and below, the river subdivides into smaller channels and large areas of silt and mud are exposed, prohibiting access to the take out.

When Pearce Ferry is inaccessible as a takeout, boaters must continue downstream to South Cove, an additional 16 miles. This costs river runners fuel (for motorized craft), time (one to two more hours on the river) and possible safety problems (due to fatigue). For commercial boaters, the additional travel time to South Cove can also result in lost business by preventing guides from meeting river tour schedules.

#### 3.9.2.2.4.1 Threshold Elevations

The description of facilities above identifies several pool elevations where facilities or access to facilities would be affected. At Las Vegas Bay, 1190 feet msl was identified as an elevation at which facilities would require adjustment, but would continue to be operable. Elevation 1180 feet msl was identified by the NPS as the elevation at which most other developed facilities would require capital expenditures, rather than just an adjustment, in order to maintain operation. Elevation 1183 feet msl was identified by the Hualapai Tribe in their comments on the DEIS as a threshold elevation for using the undeveloped Pearce Ferry site as a takeout for rafts and other whitewater boats.

The DEIS evaluated the consequences of elevation 1180 feet msl for facilities at Lake Mead (Section 3.9.2.3.2). In response to the Hualapai Tribe's comment on the DEIS regarding the threshold elevation of 1183 for Pearce Ferry, this FEIS evaluates the consequences of 1183 feet msl instead of 1180 feet msl. Therefore, 1183 feet msl is used as a representative threshold elevation for shoreline facilities and public access at Lake Mead and is used in the Environmental Consequences section (Section 3.9.2.3.2) to evaluate the effects of baseline conditions and interim surplus criteria alternatives on shoreline facilities and public access at Lake Mead.

### 3.9.2.3 ENVIRONMENTAL CONSEQUENCES

Recreational boating on Lake Mead and Lake Powell is dependent upon access to the water via public shoreline facilities such as marinas, docks and boat ramps, as well as undeveloped launch areas. Some fluctuation in water level is a normal aspect of reservoir operations, and facilities are designed and operated to accommodate it. However, decreased pool elevations or increased variations or rates in pool elevation fluctuation could result in increased operation costs, facility improvements, temporary closures, or possibly permanent closure of shoreline facilities.

As lake levels fluctuate, developed facilities must be adjusted accordingly. This could require moving and relocating docks, extending utility lines associated with shoreline facilities, increasing sewage pump capacity, reducing pressure on water supply lines to boats, adjusting and relocating buoys, moving breakwater barriers and channel markers, and extending launch and dock ramps (Combrink and Collins, 1992). If lake fluctuations exceed 25 feet, special adjustments to lake facilities would be necessary, including the relocation of anchors and the extension or reduction of utility lines and cables that provide utility service to floating facilities (Combrink and Collins, 1992).

In addition, if developed facilities are temporarily or permanently closed or relocated, or undeveloped sites are no longer accessible, there may be associated increases in reservoir boating congestion or longer wait times at sites that remain open. This could have an effect on boating satisfaction. The cost of relocating developed facilities in response to changes in reservoir pool elevations is discussed in Section 3.9.6.

### 3.9.2.3.1 Lake Powell

As discussed in the Affected Environment section above, pool elevations of 3677 feet msl and 3612 feet msl were identified as representative thresholds that are problematic for shoreline facilities at Lake Powell. Elevation 3677 feet msl was identified as a threshold elevation for the existing Antelope Point, and the NPS identified 3612 feet msl as a threshold for several other facilities. These are elevations below which facility adjustments or capital improvements would be required.

There are two other threshold elevations not treated directly below. Elevation 3626 feet msl has also been defined as a threshold elevation for the design boat ramp at Antelope Point. This elevation is discussed in Section 3.9.3.3.1. Facilities at Rainbow Bridge would be affected by pool elevations of 3650 feet msl or below, as described above in Section 3.9.2.2. Although specific probabilities of remaining above elevation 3650 feet msl were not determined, the probabilities that lake elevations would remain above 3650 feet msl would be between the probabilities for the threshold elevations of 3677 and 3612 feet msl, which are discussed below.

Figure 3.9-1 provides an overview of the differences in end-of-July water surface elevation trends under baseline conditions and the action alternatives over the period of analysis.

Figure 3.9-2 and Table 3.9-4 indicate the probability of Lake Powell elevation exceeding the threshold of 3677 feet msl in July. The probability would decrease the

**Figure 3.9-1**
**Lake Powell End of July Water Elevations**
**Comparison of Surplus Alternatives to Baseline Conditions**
**$90^{th}$, $50^{th}$ and 10th Percentile Values**

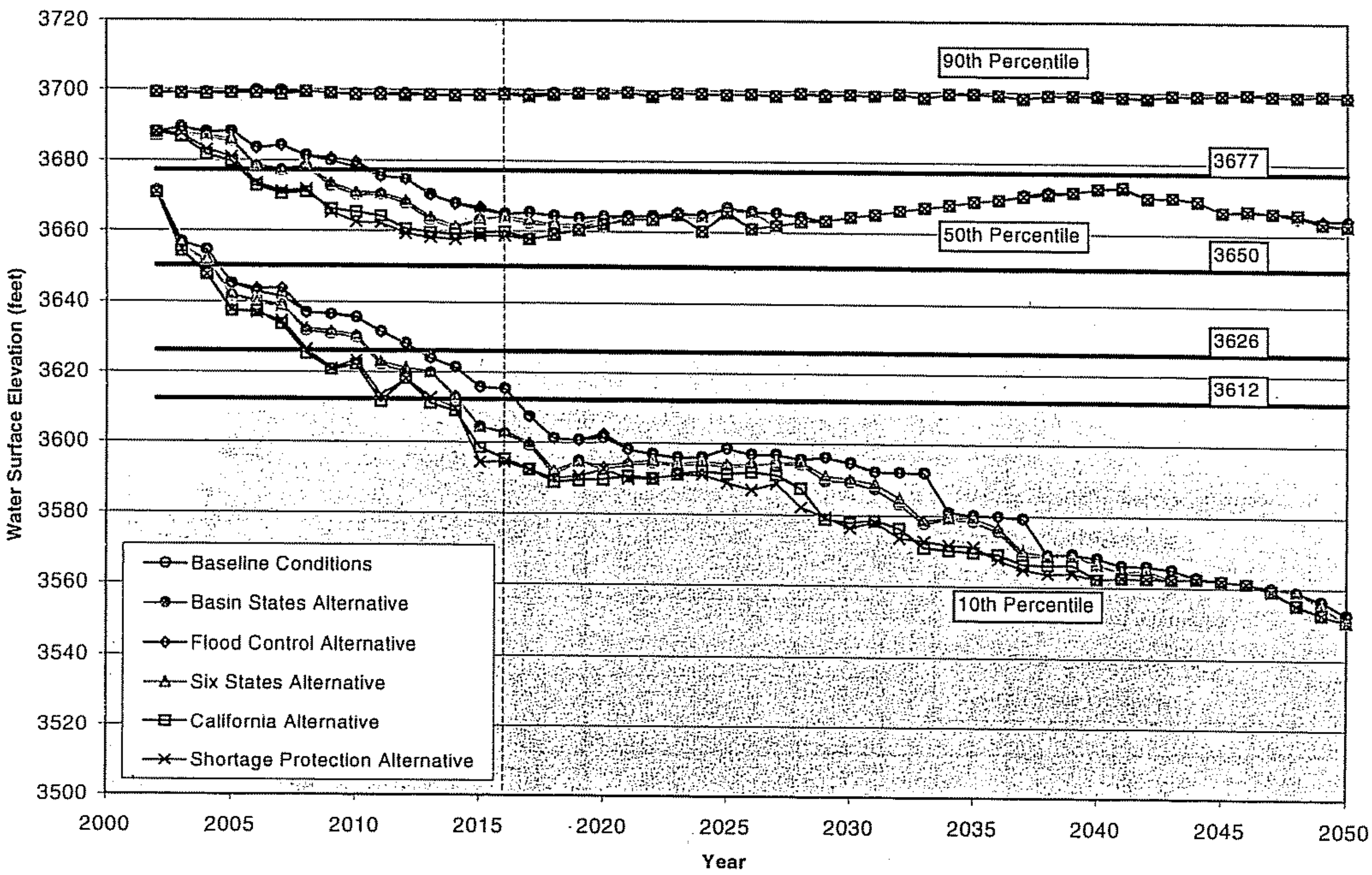
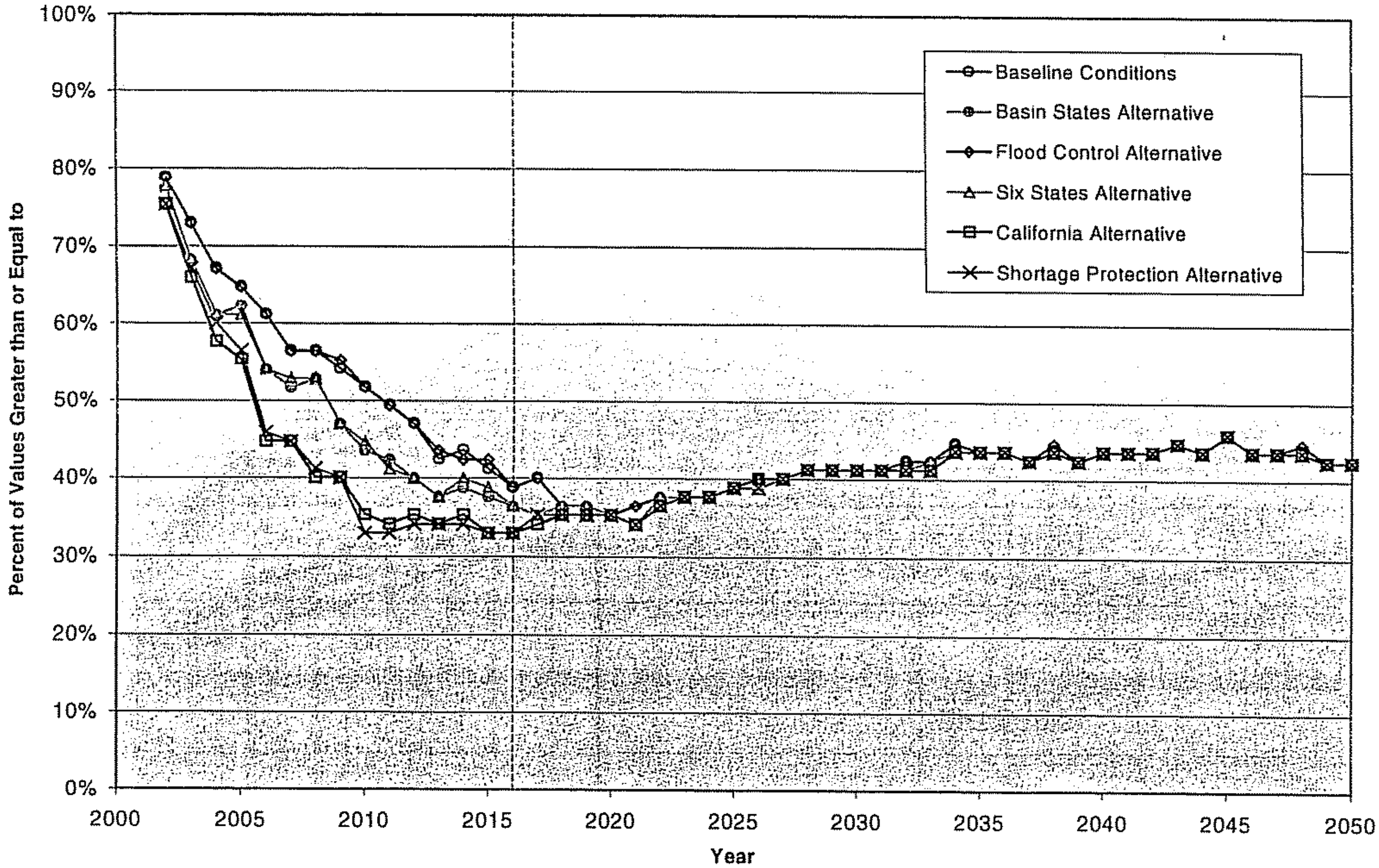


**Figure 3.9-2**
**Lake Powell End of July Water Elevations**
**Comparison of Surplus Alternatives to Baseline Conditions**
**Percent of Values Greater than or Equal to 3677 Feet msl**



most over the initial 15 years of the period of analysis. During this time, the probability would decline from nearly 80 percent to less than 40 percent under baseline conditions and the alternatives. During years 16 through 25 the effects of the alternatives would diminish, although the probability of exceeding elevation 3677 feet msl would remain low (roughly 30-40 percent). After year 25 there would be no discernable effect of the alternatives for the remainder of the analysis period; the probability of exceeding elevation 3677 feet msl would remain fairly low at around 40 to 45 percent.

The differences between the alternatives would be most apparent during the first 15 years. The greatest difference occurs in year nine, when the difference between baseline conditions and the Shortage Protection Alternative is 19 percent. The Flood Control Alternative, with results that are nearly identical to those of baseline conditions, has the lowest probability of pool elevations dropping below 3677 feet msl, whereas the Shortage Protection and California alternatives have the highest probability. The Basin States and Six States alternatives have probabilities between the baseline conditions and the Shortage Protection Alternative.

**Table 3.9-4**
**Probabilities of Lake Powell Elevation Exceeding 3677 feet in July**

| Alternative | Range of Probability | | |
|---|---|---|---|
| | Years 1-15 | Years 16 - 25 | Years 26 – 49 |
| Baseline Conditions | 79%-39% | 40%-34% | 46%-40% |
| Basin States Alternative | 78%-36% | 39%-34% | 46%-40% |
| Flood Control Alternative | 79%-39% | 40%-35% | 46%-40% |
| Six States Alternative | 78%-36% | 39%-34% | 46%-40% |
| California Alternative | 75%-33% | 40%-34% | 46%-40% |
| Shortage Protection Alternative | 75%-33% | 39%-34% | 46%-40% |

The probability of Lake Powell pool elevation exceeding the threshold of 3612 feet msl in July under baseline conditions and each of the alternatives is shown in Figure 3.9-3 and Table 3.9-5. The probability is greater than 70 percent throughout the period of analysis. The probability begins at 100 percent, due to the relatively full initial elevation, and declines gradually throughout the period of analysis. In general, probabilities decrease within a 10 to 15 percent range during the initial 15-year period, followed by an additional 10 to 15 percent decrease from years 16 through 34. For the remainder of the analysis period, decreases are around 5 percent.

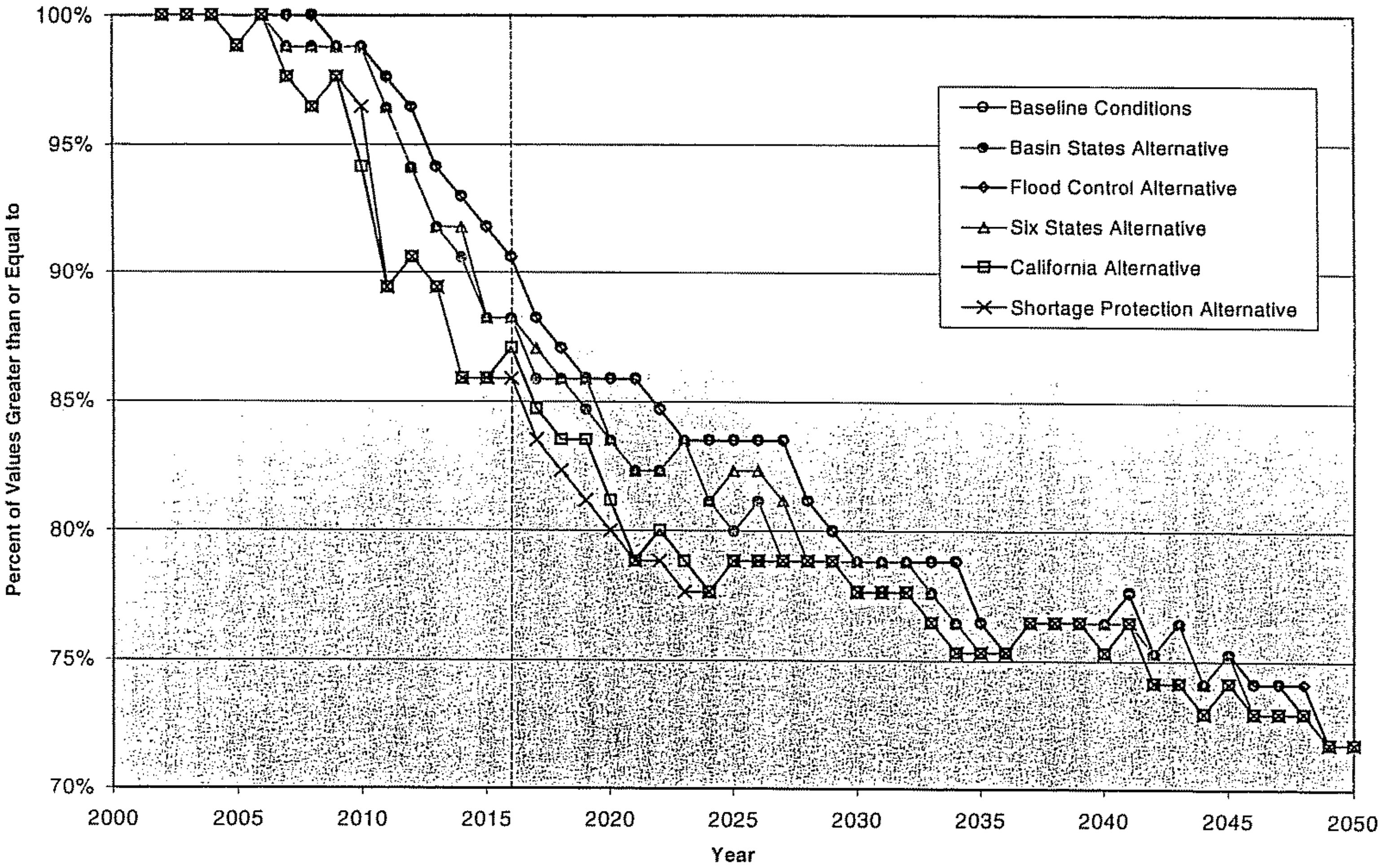
The differences between the alternatives is slight, with the greatest difference in probabilities being about eight percent. The Flood Control Alternative has the same probabilities as baseline conditions and therefore would have no effect. The other alternatives have probabilities less than or equal to baseline conditions. The Shortage Protection and California Alternatives have effects similar to each other and result in the greatest departure (maximum eight percent) from baseline conditions. The Six States and Basin States alternatives are between the Shortage Protection Alternative and baseline conditions, and have a maximum departure of five percent from baseline conditions.

Each of the alternatives is discussed below in more detail with respect to the patterns indicated on Figures 3.9-2 and 3.9-3 and Tables 3.9-4 and 3.9-5.

**Table 3.9-5**
**Probabilities of Lake Powell Elevation Exceeding 3612 feet in July**

| Alternative | Range of Probability | | |
|---|---|---|---|
| | Years 1-15 | Years 16-34 | Years 35-49 |
| Baseline Conditions | 100%-91% | 88%-76% | 78%-72% |
| Basin States Alternative | 100%-88% | 86%-75% | 76%-72% |
| Flood Control Alternative | 100%-91% | 88%-76% | 78%-72% |
| Six States Alternative | 100%-88% | 87%-75% | 76%-72% |
| California Alternative | 100%-87% | 85%-75% | 76%-72% |
| Shortage Protection Alternative | 100%-86% | 84%-75% | 76%-72% |

Figure 3.9-3
Lake Powell End of July Water Elevations
Comparison of Surplus Alternatives to Baseline Conditions
Percent of Values Greater than or Equal to 3612 Feet msl



### 3.9.2.3.1.1 Baseline Conditions

The probability under baseline conditions that Lake Powell pool elevation is above 3677 feet msl in July decreases from 79 percent in year 1 to 39 percent in year 15. In years 16 through 25, the probability ranges between 40 and 34 percent. For the remainder of the analysis period the probability ranges between 40 and 46 percent. The early declining probabilities (for baseline conditions and alternatives) can be mostly attributed to increasing consumptive use of Colorado River water in the Upper Basin. The later rise is attributed to the suspension of equalization requirements between Lake Powell and Lake Mead (see Section 1.4.2).

There is a high probability that July Lake Powell pool elevation would exceed the threshold of 3612 feet msl for the baseline condition throughout the period of analysis. Between years 1 and 15, the probability decreases from 100 percent to 91 percent. Between years 16 and 34, the probability continues to decrease gradually from 88 percent to 76 percent. For the remainder of the analysis period, the probability decreases slightly, ranging between 78 and 72 percent. The declining trend of all probabilities (baseline conditions and alternatives) can be mostly attributed to increasing consumptive use of Colorado River water in the Upper Basin.

### 3.9.2.3.1.2 Basin States Alternative

The probability of the Lake Powell pool elevation exceeding 3677 feet msl in July is slightly lower under the Basin States Alternative than under baseline conditions. In the first 15 years, the probability decreases from 78 percent to 36 percent under the Basin States Alternative. The probability during this period is one percent to eight percent lower than under baseline conditions. In years 16 to 25, the probability decreases to a low of 34 percent, then rises to 39 percent. During this period, the probability is generally the same as for baseline conditions. For the remainder of the analysis period, probabilities fluctuate between 40 and 46 percent, and are generally the same as under baseline conditions.

The probability of Lake Powell elevation exceeding 3612 feet msl in July under the Basin States Alternative is slightly lower than for the baseline conditions. Between years 1 and 15, the probability decreases from 100 percent to 88 percent, compared to a 91 percent probability under baseline conditions. During this period, the probability is typically up to two percent less than under baseline conditions. Between years 16 and 34, the probability continues a gradual decline to 75 percent, and ranges between zero and five percent less, but typically between zero and two percent less, than under baseline conditions. For the remaining years of analysis, the probability continues to decline to a low of 72 percent in year 2050, and is within one percent of the probability under baseline conditions.

#### 3.9.2.3.1.3 Flood Control Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl under the Flood Control Alternative is approximately the same as for baseline conditions. In the first 15 years, the probability decreases from 79 to 39 percent, and is within one percent of the probability under baseline conditions. From years 16 to 25, the probability fluctuates between 40 and 35 percent. The probability during this period is typically the same as under baseline conditions. By the end of the period of analysis, the probability remains fairly constant, between 40 and 46 percent. During this period, the probability is typically the same as under baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the Flood Control Alternative is generally the same as that described for baseline conditions throughout the period of analysis.

#### 3.9.2.3.1.4 Six States Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl under the Six States Alternative is very similar to the Basin States Alternative discussed above. In early years, the probability is up to seven percent less than under baseline conditions. In later years, the probability is generally the same as under baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the Six States Alternative is also very similar to the Basin States Alternative. In early years, the probability is up to four percent less than under baseline conditions. In later years, the probability is typically the same as under baseline conditions.

#### 3.9.2.3.1.5 California Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl is lower under the California Alternative than under baseline conditions. In the first 15 years, the probability declines from 75 percent to a low of 33 percent, and ranges from 4 to 16 percent less than under baseline conditions. In years 16 to 25, the probability increases slightly, ranging from 34 to 40 percent, and is typically the same as under baseline conditions. For the remainder of the analysis period, the probability increases slightly, remaining between 40 and 46 percent, and is always within one percent of baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the California Alternative is slightly lower than under baseline conditions. Between years 1 and 15, the probability decreases from 100 percent to 87 percent and is from zero to eight percent less than under baseline conditions. The probability continues to decrease from 85 to 75 percent in years 16 through 34, and is up to seven percent less than under baseline conditions. For the remaining years of analysis, the probability ranges between 76 and 72 percent, and is from zero to two percent less than under baseline conditions.

#### 3.9.2.3.1.6 Shortage Protection Alternative

The probability of Lake Powell pool elevation exceeding 3677 feet msl under the Shortage Protection Alternative is not significantly different from the California Alternative discussed above. In early years, the probability is up to 19 percent less than under baseline conditions. In later years, the probability is typically the same as under baseline conditions.

The probability of Lake Powell pool elevation exceeding 3612 feet msl under the Shortage Protection Alternative is not significantly different from the California Alternative discussed above. In early years, the probability is up to eight percent less than under baseline conditions. In later years, the probability is within two percent of the probability under baseline conditions.

#### 3.9.2.3.2 Lake Mead

As discussed in the Affected Environment section above, a pool elevation of 1183 feet msl was identified as a representative threshold that is problematic for shoreline access at Lake Mead. Figure 3.9-4 provides an overview of the difference in end-of-year water surface elevations under baseline conditions and each of the action alternatives. Although elevations would typically be lower during the summer peak-use period, the differences between baseline conditions and action alternatives would be similar to those presented herein.

Figure 3.9-5 and Table 3.9-6 indicate the probability of Lake Mead elevation exceeding the threshold of 1183 feet msl at the end of the year. As shown in Figure 3.9-5, the probability is low over the period of analysis due primarily to effects associated with baseline conditions. In the initial 15 years of analysis, the probabilities under baseline conditions and the alternatives decline by more than 20 percent. Shortly after year 15, the probabilities under baseline conditions and the alternatives converge near 35 percent. Subsequently, a probability of 28 to 36 percent is maintained until the end of the analysis period.

**Table 3.9-6**
**Comparison of Lake Mead Elevation Exceedance Probabilities for Elevation 1183 Feet**

| Alternative | Year 0-15 | Years 16 - 49 |
|---|---|---|
| Baseline Conditions | 65%-36% | 36%-29% |
| Basin States Alternative | 55%-32% | 35%-29% |
| Flood Control Alternative | 65%-36% | 38%-29% |
| Six States Alternative | 55%-32% | 35%-29% |
| California Alternative | 45%-25% | 35%-28% |
| Shortage Protection Alternative | 47%-26% | 34%-28% |

Figure 3.9-4
Lake Mead End of December Water Elevations
Comparison of Surplus Alternative to Baseline Conditions
$90^{th}$, $50^{th}$ and $10^{th}$ Percentile Values

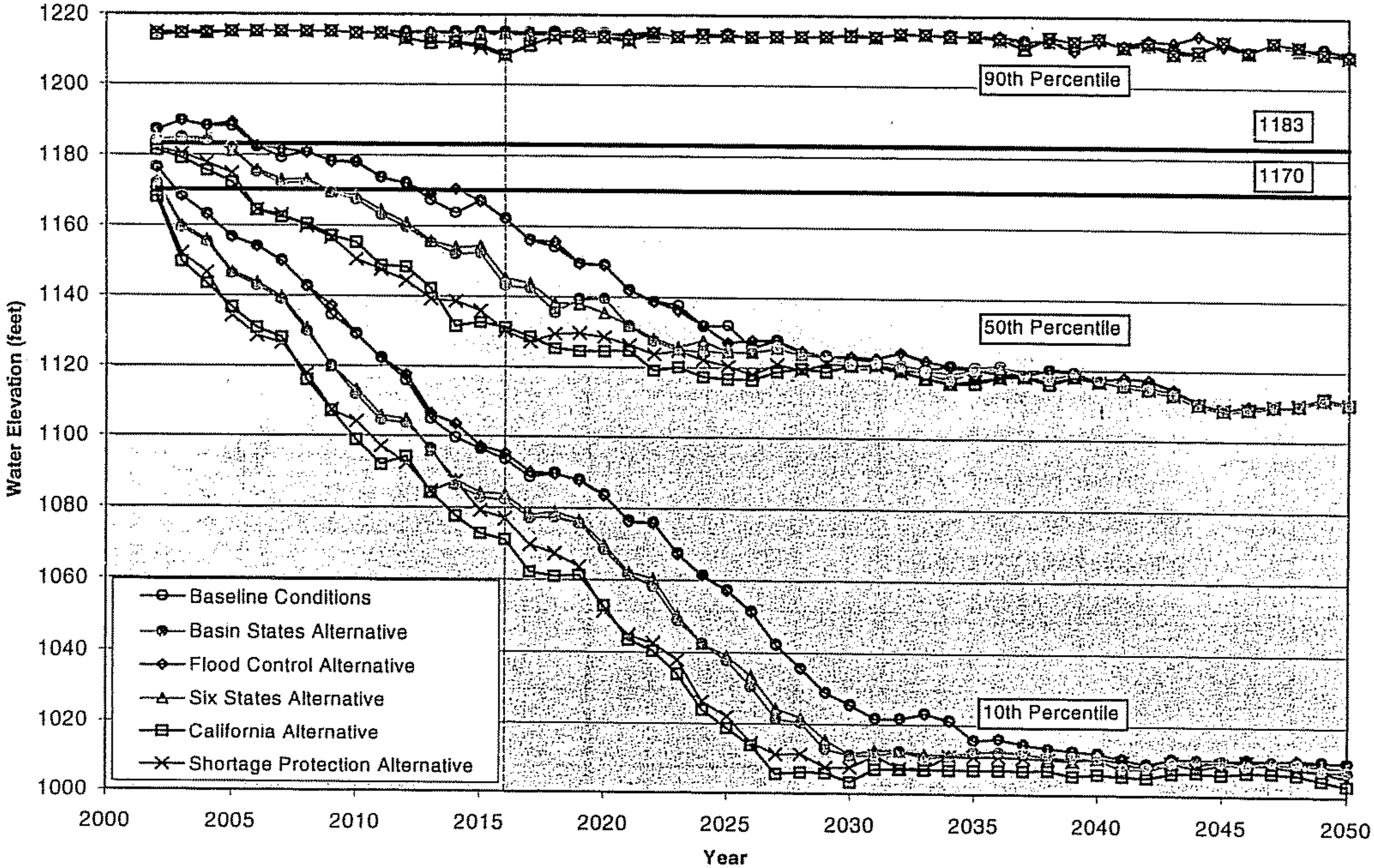
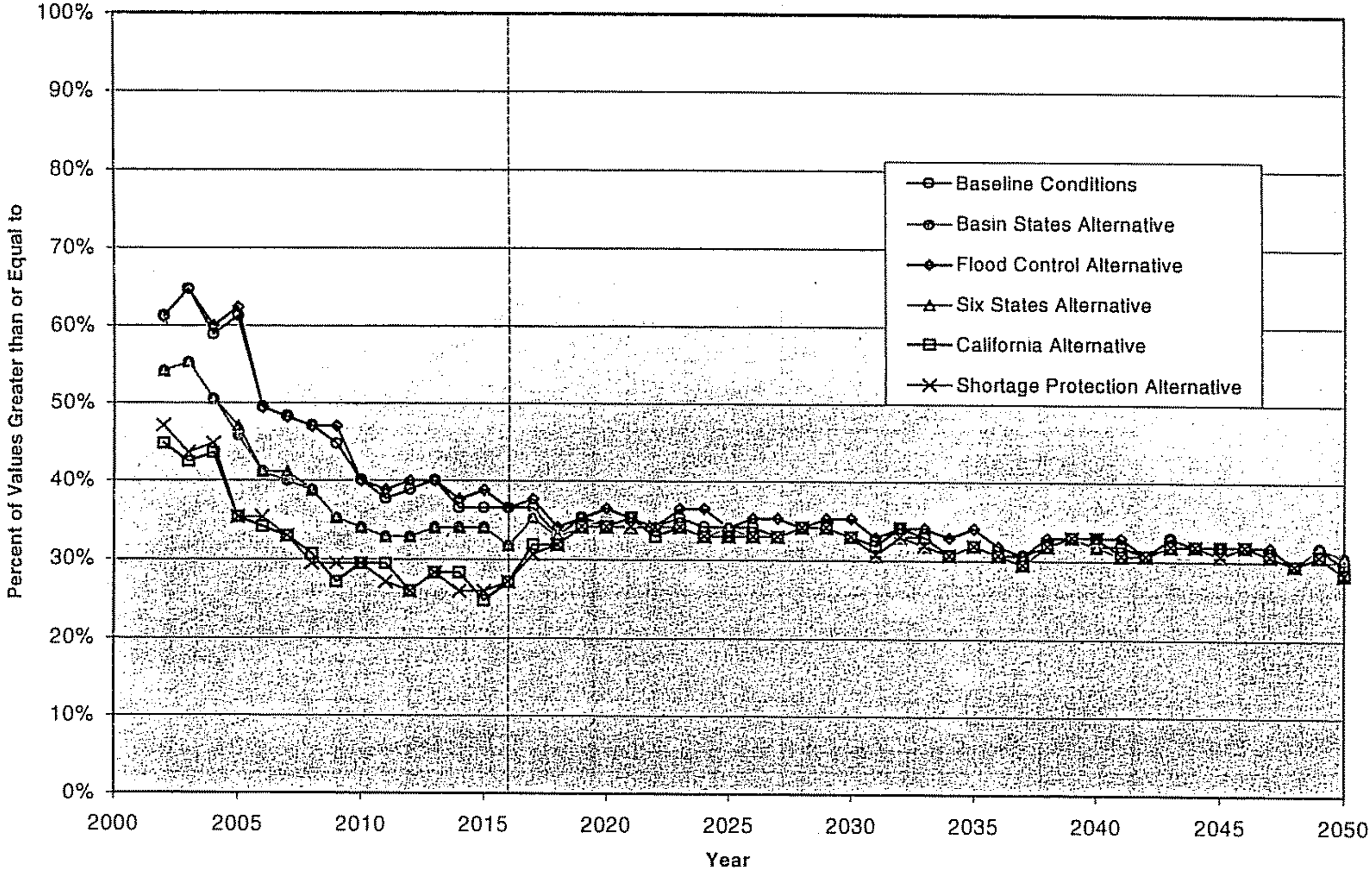


**Figure 3.9-5**
**Lake Mead End of December Water Elevations**
**Comparison of Surplus Alternatives to Baseline Conditions**
**Percent of Values Greater than or Equal to 1183 Feet msl**



#### 3.9.2.3.2.1 Baseline Conditions

The probability of Lake Mead pool elevation exceeding 1183 feet msl declines from 65 percent to 36 percent under baseline conditions during the first 15 years of the analysis period. In the remaining years of the analysis period, the probability ranges between 36 and 29 percent. The general declining trend of Lake Mead elevations over time can be attributed to increases in Upper Basin use.

#### 3.9.2.3.2.2 Basin States Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl in the first 15 years of the analysis period declines from 55 percent to 36 percent under the Basin States Alternative. The probability during this period is typically up to nine percent less than under baseline conditions. In remaining years of the analysis period, the probability ranges between 35 and 29 percent. During this period, the probability is within one percent of the probability under baseline conditions.

#### 3.9.2.3.2.3 Flood Control Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl in the first 15 years of the analysis period declines from 65 percent to 36 percent under the Flood Control Alternative. In remaining years of the analysis period, the probability ranges between 38 and 29 percent. The probability of exceeding elevation 1183 feet msl under the Flood Control Alternative would be approximately the same as under baseline conditions throughout the entire analysis period.

#### 3.9.2.3.2.4 Six States Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl in the first 15 years of the analysis period declines from 55 percent to 32 percent under the Six States Alternative. In remaining years of the analysis period, the probability ranges between 35 and 29 percent. The probability is nearly identical to that for the Basin States Alternative discussed above.

#### 3.9.2.3.2.5 California Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl is lowest under the California Alternative in most years. In the first 15 years, the probability ranges between 45 and 25 percent. This is up to 26 percent lower than under baseline conditions. After year 16, the probability is within one percent of the probability under baseline conditions.

#### 3.9.2.3.2.6 Shortage Protection Alternative

The probability of Lake Mead pool elevation exceeding 1183 feet msl under the Shortage Protection Alternative is nearly the same as under the California Alternative. In the first 15 years, the probability ranges between 47 and 27 percent and is up to 26 percent lower than under baseline conditions. After year 16, the probability associated with the Shortage Protection Alternative generally converges with baseline conditions and the other alternatives, similar to the California Alternative.

## 3.9.3 RESERVOIR BOATING/NAVIGATION

This section discusses potential effects of the interim surplus criteria on reservoir boating and navigation. This includes a discussion of areas on the reservoir that could become unsafe for boating at certain elevations due to exposed rocks or other obstructions, and safe boating densities that indicate the number of boats that can safely be accommodated on the reservoirs at one time.

Boating navigation and safe boating capacities on Lake Powell and Lake Mead are dependent upon water surface elevations. As lake levels decline, so does the available surface area. Hazards such as exposed rocks may become more evident, or changes in navigation patterns may be necessary. The area of the reservoirs available for boating is also reduced, which may affect the number of boats that can safely operate at one time. At low pool elevations, special buoys or markers may be placed to warn boaters of navigational hazards. In addition, signs may be placed in areas that are deemed unsuitable for navigation.

### 3.9.3.1 METHODOLOGY

Description of the affected environment is based on a literature review of published and unpublished documents and maps, and personal communications with NPS staff at the GCNRA and LMNRA. Information received includes the identification of navigation issues associated with recreational boating on Lake Powell and Lake Mead, such as navigation safety and safe boating densities. Low reservoir pool elevations identified in the literature or through discussions with NPS as being of concern for reservoir boating and navigation are discussed herein. Assessment of environmental consequences associated with implementing the interim surplus criteria alternatives is based on river system modeling and probability analyses of Lake Powell and Lake Mead pool elevations exceeding identified thresholds.

Safe boating capacity is another aspect of boating navigation and safety. Safe boating is one factor that can be used to assess the carrying capacity of a reservoir. To date, no determination of carrying capacity (number of boats at one time) has been made for either Lake Powell or Lake Mead However, the NPS is currently developing a carrying capacity approach for managing water-based recreation on Lake Mead that is based on the U.S. Forest Service Recreation Opportunity Spectrum system. Results of the NPS study were not available for this analysis.

A safe boating density of nine acres per boat was established for the GCNRA (USBR, 1995b) at Lake Powell. The safe boating density could be used to assess the effects of the interim surplus criteria alternatives on boating safety if daily boating levels for the reservoir were available. However, there is no known information on the level of daily or peak boating use, such as whether the current boating densities on the reservoirs have approached or exceeded the safe boating density (as discussed below). Without information on current reservoir boat densities, it is not known whether future reductions in pool elevations at Lake Powell and Lake Mead would result in unsafe boating conditions.

### 3.9.3.2 AFFECTED ENVIRONMENT

#### 3.9.3.2.1 Lake Powell Boating Navigation and Safety

In 1986, the GCNRA developed an "Aids to Navigation Plan" for Lake Powell that identified boating safety issues on the reservoir and low pool elevations that could affect boating (NPS, 1986). The navigation system uses regulatory buoys and other marking devices to warn boat operators of hazardous conditions associated with subsurface obstructions or changes in subsurface conditions that could be hazardous for safe passage. Placement of many of these marking devices is dependent on the lake elevation.

At pool elevations below 3680 feet msl, there are several places that remain passable, although buoys are placed for safe navigation. At elevation 3626 feet msl and 3620 feet msl, there are two areas on the reservoir that are closed to commercial tour boats and recreational boats, respectively, because of hazardous obstructions to navigation. One of the areas is around Castle Rock, just east of the Wahweap Marina, and the other is around Gregory Butte, which is about midway to Dangling Marina from Wahweap (as shown on Map 3.9-1). At elevation 3626 feet msl commercial tour boats leaving the Wahweap Marina heading up reservoir (east) must detour 8.5 miles around the southern end of Antelope Island. At Gregory Butte, commercial tour boats must detour 4.5 miles around Padre and Gregory Buttes (NPS, 1986). The added mileage and increased travel time makes the more popular half-day trips of the area infeasible for commercial tour boat operators. In addition, the added mileage may influence recreational boaters to remain in the area of Wahweap Bay, which can result in congestion (Henderson, 2000).

In addition to buoys marking obstructions, the Aids to Navigation Plan also established a marked travel corridor to guide boat travel on Lake Powell. This primary travel corridor is the main channel of the old Colorado River bed and is marked with buoys along the entire length of the reservoir. Except for the reservoir mouth, there are no known pool elevations at which boat passage along this main travel corridor becomes restricted and affects boating.

Near the upstream end of the reservoir, where the San Juan River enters, a delta has formed that can affect river boaters coming into Lake Powell at low pool elevations. River boaters from the San Juan River paddle through Lake Powell to a location where a boat transports them 20 to 25 miles (depending on the pick-up location) to the Hite Marina. At low water surface elevations, the river boaters must travel further downstream to reach a location that is accessible to the transport company's boat.

Although this results in more miles to paddle to the takeout, there is usually enough current in the river to carry the boats. For some boaters, the added mileage is an opportunity to paddle additional rapids on the Colorado River in Cataract Canyon (Hyde, 2000). For others, the additional mileage is seen as exposure to additional navigational hazards, possibly requiring portaging of boats due to restricted channel widths and subsurface conditions.

#### 3.9.3.2.1.1 Lake Powell Safe Boating Capacity

Recreational boating is the most frequent type of boating activity on Lake Powell, with an estimated 1.5 million boaters per year. One of the most popular activities at Lake Powell is to take houseboats and motor boats for multiple day excursions to explore the reservoir.

The number of boats that Lake Powell can safely accommodate at one time (i.e., safe boating capacity) is based on a 1977 Bureau of Outdoor Recreation standard of nine surface acres per boat (USBR, 1995b). The amount of water storage in Lake Powell directly influences the surface area of the reservoir and the number of boats that can safely be on the reservoir. Table 3.9-7 lists median July Lake Powell surface areas for baseline conditions and alternatives in the year 2016 and identifies the safe boating capacity of the reservoir at those elevations, based on an assumed maximum safe density of nine acres per boat. The surface area of Lake Powell is reduced by approximately 9 to 10 percent for each 20-foot drop.

Table 3.9-7
Lake Powell Safe Boating Capacity at Water Surface Elevations

| Scenario | Median Elevation in July of Year 15 (feet msl) | Water Surface Area (acres) | Safe Boating Capacity[1] |
|---|---|---|---|
| Baseline Conditions | 3665 | 134,600 | 14,956 |
| Basin States Alternative | 3664 | 134,100 | 14,900 |
| Flood Control Alternative | 3665 | 134,600 | 14,956 |
| Six State Alternatives | 3664 | 134.100 | 14,900 |
| California Alternative | 3660 | 130,800 | 14,533 |
| Shortage Protection Alternative | 3659 | 130,200 | 14,467 |

1 Number of boats, assuming safe density of 9 acres per boat.

At full pool for Lake Powell (3700 feet msl), the surface area is 160,782 acres. Using the safe boating density of nine surface acres per boat, Lake Powell's safe boating capacity at full storage is approximately 17,865 boats. As pool elevation decreases, the surface area available for boats also decreases. While safe reservoir boating carrying capacity is reduced at lower lake elevations, there may be additional shoreline camping available due to more exposed beaches. However, boating capacity is more constrained by safe boating densities than by the availability of camping sites on Lake Powell (Combrink and Collins, 1992).

### 3.9.3.2.2 Lake Mead Boating Navigation and Safety

Similar to the navigation system on Lake Powell, regulatory buoys and other marking devices are used on Lake Mead to warn boat operators of dangers, obstructions, and changes in subsurface conditions in the main channel or side channels.

As with Lake Powell, the main channel of the old Colorado River bed forms the primary travel corridor on Lake Mead and is marked along its entire length with buoys for boating guidance. In addition, regulatory buoys are placed in areas where there may be a danger for safe passage.

Excursions from Lake Mead into the Grand Canyon are a popular activity. Boats entering the Grand Canyon usually launch at Pearce Ferry, South Cove or Temple Bar (refer to Map 3.9-2). There are no developed facilities at South Cove or Pearce Ferry. Points of interest in the Grand Canyon include Columbine Falls, Bat Cave, Spencer Creek, and Separation Canyon. In addition to sightseeing being a popular activity, many boaters include overnight camping stays on these excursions (USBR, 1995b).

The upper arms and inflow areas of Lake Mead are considered dangerous for navigation due to shifting subsurface sediments. In the main channel of the reservoir, the Grand

Wash Cliffs area is the beginning of dangerous navigation conditions, and no houseboats are allowed beyond this point (NPS, undated).

Over the years, sediment has built up in the section of the reservoir between Grand Wash and Pearce Ferry. When lake elevations drop below 1170 feet msl, the sediment is exposed as mud flats and there is no well-defined river channel. As a result, the area is too shallow for motor boats to navigate upstream and into the lower reaches of the Grand Canyon. With fluctuating flows, even smaller crafts have a difficult time accessing the area because of the shifting nature of the channel (USBR, 1995b). Based on this information, 1170 feet msl is considered a threshold elevation for safe boating navigation at Lake Mead.

While the area around Pearce Ferry is an issue for navigation at 1170 feet msl, it is also inaccessible as a take out for whitewater boaters at elevation 1183 feet msl and boaters must paddle an additional 16 miles to South Cove (Henderson, 2000). Paddling to South Cove includes paddling through the section of reservoir between Pearce Ferry and Grand Wash. (Refer to Section 3.9.2.2.3 for a description of the Pearce Ferry facility, and Section 3.9.2.3.2 for an analysis of environmental consequences associated with elevation 1183 feet msl.)

In addition to the boating navigation issues summarized above, there are swimmer safety issues at Lake Mead. At Gypsum Wash (between Las Vegas Bay and Government Wash), there are cliffs that are popular with recreationists for jumping into the lake. When lake elevations are below 1180 feet msl, the water is too shallow for cliff jumping from this location. Another jumping spot that was poplar during the late 1980's when reservoir levels were down is an area called "33 Hole." This location is popular for cliff jumping when the lake elevation reaches 1165 feet msl. Cliff jumping at both locations is discouraged by the NPS for safety reasons (Burke, 2000). Since the activity is discouraged, the identified elevations were not considered as thresholds for evaluation of effects.

#### 3.9.3.2.3 Lake Mead Safe Boating Capacity

The LMNRA receives approximately ten million visitors annually. Of those that participate in water-based recreation, most either swim, boat, fish, sailboard, use paddlecraft, or scuba dive (USBR, 1996b). Since no boating capacity has been established for Lake Mead, the safe boating density of nine acres per boat established for Lake Powell was assumed; safe boating capacities were determined based on reservoir elevation/surface area relationships. There is no daily or peak boating use information available to establish the relationship between actual boating densities and the safe boating capacity values shown below in Table 3.9-8. This table shows Lake Mead surface area under the predicted pool elevations for baseline conditions and the alternatives at the end of 2016, and identifies the safe boating capacity of the reservoir based on an assumed maximum safe density of nine acres per boat.

**Table 3.9-8**
**Lake Mead Safe Boating Capacity at Water Surface Elevations**

| Scenario | Median Elevation at End of Year 15 (feet msl) | Water Surface Area (acres) | Safe Boating Capacity[1] |
|---|---|---|---|
| Baseline Conditions | 1162 | 120,200 | 13,356 |
| Basin States Alternative | 1143 | 108,100 | 12,011 |
| Flood Control Alternative | 1162 | 120,200 | 13,356 |
| Six State Alternatives | 1145 | 109,400 | 12,156 |
| California Alternative | 1131 | 102,100 | 11,344 |
| Shortage Protection Alternative | 1130 | 101,700 | 11,300 |

[1] Number of boats, assuming safe density of 9 acres per boat.

At full pool for Lake Mead, the operating surface area is 153,235 acres. Using the safe boating density of nine surface acres per boat, Lake Mead's safe boating capacity at full storage is approximately 17,000 boats. As pool elevation decreases, the safe boating capacity also decreases.

### 3.9.3.3 Environmental Consequences

Boating navigation and safe boating densities on Lake Powell and Lake Mead are dependent upon water surface elevations. As lake levels fluctuate, hazards, such as exposed rocks at lower pool elevations or different navigational patterns at higher elevations, may become evident. At low pool elevations, special buoys or markers may be placed to warn boaters of navigational hazards. In addition, signs may be placed in areas deemed unsuitable for navigation.

Assessment of environmental consequences of the alternatives on boating navigation and safety is based on river system model output, described in detail in Section 3.3. The probability of effects under baseline conditions and the alternatives was determined through identifying the probability of exceeding a representative "threshold" pool elevation during the period of analysis. The selection of the threshold pool elevation is based on the known boating navigation issues discussed in the Affected Environment section above. The probabilities of the reservoirs remaining above the identified threshold elevations are identified for baseline conditions and the interim surplus criteria alternatives, and differences between probabilities under baseline conditions and alternatives are compared.

In addition to navigation issues that occur at low pool elevations, the number of boats that can safely be accommodated on the reservoir at one time (safe boating capacity) is also a reservoir boating issue. As discussed previously, the lack of boating use data and spatial modeling of the effects of the alternatives on shoreline conditions precludes a quantitative or qualitative assessment of the impacts associated with the alternatives. In general, as pool elevations change, so does the reservoir surface area and the number of boats that can safely be accommodated on the reservoir. Therefore, the alternatives that result in the greatest potential for lower surface elevations would tend to increase the likelihood of exceeding safe boating densities. Without current and projected boating use levels for comparison to surface areas under the alternatives, it cannot be determined whether the change in available surface area would result in an exceedance of the calculated safe boating capacities shown in Tables 3.9-7 and 3.9-8, so environmental consequences related to safe boating capacity are not analyzed further.

#### 3.9.3.3.1 Lake Powell

For Lake Powell boating navigation, a reservoir pool elevation of 3626 feet msl was identified as a representative threshold in Section 3.9.3.2.1. Figure 3.9-1 (presented previously) shows elevation trends for baseline conditions and the alternatives over the period of analysis.

In addition, as discussed in the section on shoreline facilities (Section 3.9.2.2.2), elevation 3626 feet msl is also close to the elevation for a new proposed boat ramp at Antelope Point, which will extend down to 3620. Using an assumption of six feet for freeboard, the environmental consequences associated with elevation 3626 for navigation are applicable to the future operability of the proposed ramp at Antelope Point.

Figure 3.9-6 depicts the probability of pool elevations exceeding 3626 feet msl under baseline conditions and each of the alternatives. Table 3.9-9 presents a comparison of the probabilities associated with years 1 through 15, 16 through 28, and 29 through 49. The probability decreases (from 100 to 65 percent) during the analysis period under baseline conditions and all of the alternatives. The probability is greatest for baseline conditions and the Flood Control Alternative, and least for the California and Shortage Protection Alternatives. The Six States and Basin States alternatives have probabilities between the others.

**Figure 3.9-6**
**Lake Powell End of July Water Elevations**
**Comparison of Surplus Alternatives to Baseline Conditions**
**Percentage of Values Greater than or Equal to 3626 Feet**

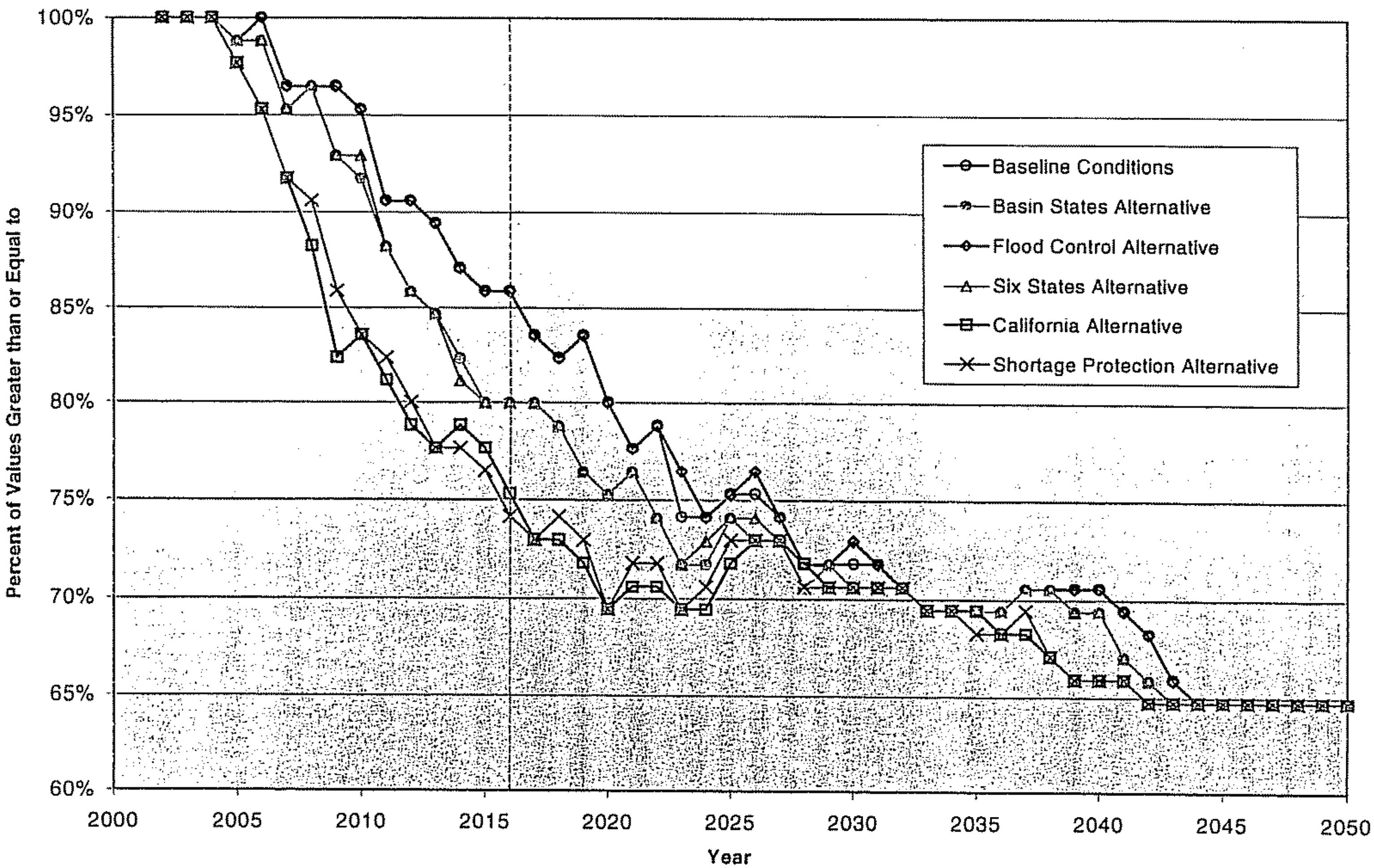


**Table 3.9-9**
**Probabilities of Lake Powell Elevation Exceeding 3626 feet in July**

| Projected Condition | Range of Probability | | |
|---|---|---|---|
| | Years 1 - 15 | Years 16 - 28 | Years 29 - 49 |
| Baseline Conditions | 100%-86% | 84%-72% | 72%-65% |
| Basin States Alternative | 100%-80% | 80%-71% | 71%-65% |
| Flood Control Alternative | 100%-86% | 84%-72% | 73%-65% |
| Six States Alternative | 100%-80% | 80%-71% | 71%-65% |
| California Alternative | 100%-75% | 73%-69% | 71%-65% |
| Shortage Protection Alternative | 100%-74% | 74%-69% | 71%-65% |

### 3.9.3.3.1.1 Baseline Conditions

The probability of Lake Powell pool exceeding the safe boating navigation elevation of 3626 feet msl in July gradually decreases from 100 percent to 65 percent under baseline conditions during the entire period of analysis. The probability decreases more slowly under baseline conditions and the Flood Control Alternative than under the other alternatives. In the first 15 years of the analysis period, the probability decreases from 100 to 86 percent. From years 16 to 28, the probability decreases from 84 to 72 percent. For the remainder of the analysis period, the probability continues to decrease, declining from 72 to 65 percent.

### 3.9.3.3.1.2 Basin States Alternative

The probability of Lake Powell pool elevation exceeding 3626 feet msl gradually decreases from 100 percent to 65 percent under the Basin States Alternative during the entire period of analysis. During the first 15 years, the probability declines more rapidly than under baseline conditions, dropping from 100 to 80 percent. The probability in year 15 is six percent less than under baseline conditions. Between years 16 and 28, the probability begins to converge with the probabilities of baseline and the other alternatives, and ranges between 80 and 71 percent. During this period, the probability is up to 7 percent less than under baseline conditions. For the remainder of the analysis period, the probability is similar to baseline conditions and the other alternatives, continuing to decline to a low of 65 percent.

### 3.9.3.3.1.3 Flood Control Alternative

For the Flood Control Alternative, the probability of Lake Powell pool elevation exceeding 3626 feet msl is practically the same as for baseline conditions throughout the analysis period. As shown in Figure 3.9-6, there are only three years in which the probability is different (within one to two percent) from baseline conditions.

### 3.9.3.3.1.4 Six States Alternative

The probability of Lake Powell elevation exceeding 3626 feet msl under the Six States Alternative is identical to the probability under the Basin States Alternative in all but four years, when there is a one percent difference.

### 3.9.3.3.1.5 California Alternative

The California Alternative results in the lowest probability of Lake Powell pool elevation exceeding 3626 feet msl. The probability decreases from 100 to 75 percent in the first 15 years of the analysis period. Between years 16 and 28, the probability begins to converge with the probabilities under baseline and the other alternatives, ranging between 73 and 69 percent. For the remainder of the analysis period, the probability is similar to baseline conditions and the other alternatives, continuing to decline to a low of 65 percent. During these three periods, the probability is up to 14 percent, 12 percent and 5 percent, respectively, below the probability under baseline conditions.

### 3.9.3.3.1.6 Shortage Protection Alternative

For the Shortage Protection Alternative, the probability of Lake Powell pool elevation exceeding 3626 feet msl is nearly the same as under the California Alternative throughout the analysis period. The probability is up to 12 percent less than under baseline conditions during the first 15 years of the analysis period. Between years 16 and 28, the probability begins to converge with the probabilities under baseline conditions and the other alternatives, and is up to 11 percent less than under baseline conditions. For the remainder of the analysis period, the probability is within 5 percent of baseline conditions.

### 3.9.3.3.2 Lake Mead

A reservoir pool elevation of 1170 feet msl was identified as the representative threshold for boating navigation at Lake Mead, as described in Section 3.9.3.2.2.

Figure 3.9-7 depicts the probability of Lake Mead end-of-December pool elevations exceeding 1170 feet msl for baseline conditions and the alternatives. Table 3.9-10 compares the probabilities associated with years 1 through 15, years 16-22, and years 23 through 49.

**Figure 3.9-7**
**Lake Mead End of December Water Elevations**
**Comparison of Surplus Alternatives to Baseline Conditions**
**Percentage of Values Greater than or Equal to 1170 Feet**

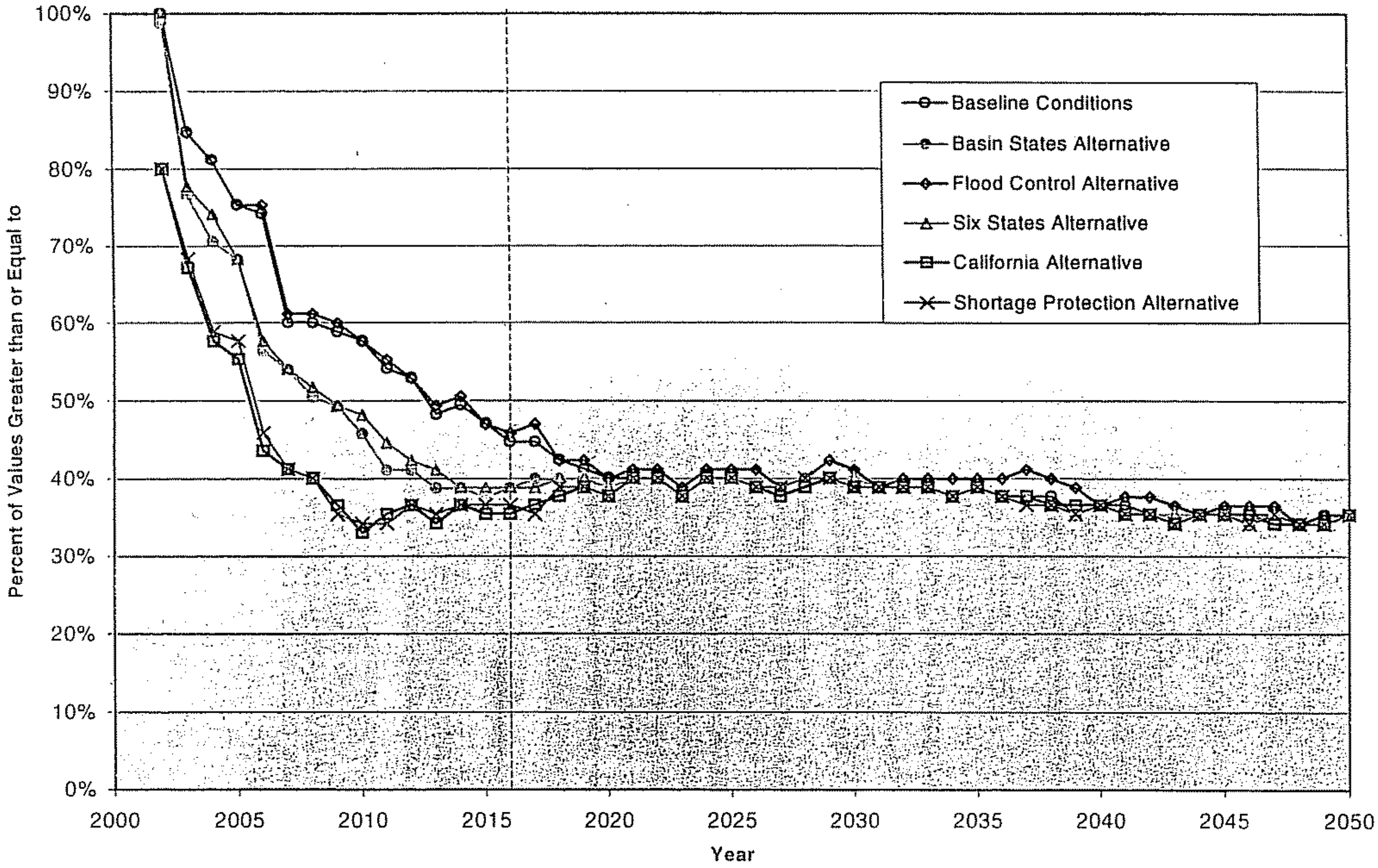


**Table 3.9-10**
**Probabilities of Lake Mead End-of-December Elevation Exceeding 1170 feet**

| Projected Condition | Range of Probability | | |
|---|---|---|---|
| | Years 1 – 15 | Years 16 - 22 | Years 23 - 49 |
| Baseline Conditions | 100%-45% | 45%-38% | 40%-34% |
| Basin States Alternative | 99%-38% | 40%-38% | 40%-34% |
| Flood Control Alternative | 100%-46% | 47%-39% | 42%-34% |
| Six States Alternative | 100%-39% | 40%-38% | 40%-34% |
| California Alternative | 80%-33% | 40%-36% | 40%-34% |
| Shortage Protection Alternative | 80%-34% | 40%-35% | 40%-34% |

Under baseline conditions and the alternatives, the probability of Lake Mead pool elevation exceeding 1170 feet msl declines during the interim period, then stabilizes for the remainder of the period of analysis. The probability is greatest for baseline conditions and the Flood Control Alternative, and least for the California and Shortage Protection Alternatives. The Basin States and Six States alternatives have probabilities between the others.

### 3.9.3.3.2.1 Baseline Conditions

The probability of Lake Mead pool elevation exceeding the safe boating and navigation elevation of 1170 feet msl at the end of the year declines from 100 to 34 percent under baseline conditions throughout the entire period of analysis. Probabilities decrease more slowly under baseline conditions than under all alternatives except for Flood Control. In the first 15 years of analysis, the probability declines from 100 to 45 percent. Between years 16 and 22, the probability continues to decline from 45 to 38 percent, as the alternatives converge with baseline conditions. For the remainder of the analysis period, the probability under baseline conditions is similar to the alternatives, ranging between 40 and 34 percent.

### 3.9.3.3.2.2 Basin States Alternative

The probability of Lake Mead pool elevation exceeding 1170 feet msl declines from 99 to 34 percent throughout the entire period of analysis for the Basin States Alternative. As with most other alternatives, the decrease occurs during the interim period and occurs more quickly than under baseline conditions. In the first 15 years of the analysis period, the probability drops from 99 percent to 39 percent and is typically up to 13 percent less than under baseline conditions. Between years 16 and 22, the probability stabilizes and converges with baseline conditions. The range of probability is from 40 to 38 percent, and is up to five percent less than under baseline conditions. For the remainder of the analysis period, the probability is within one percent of baseline conditions, ranging between 40 and 34 percent.

#### 3.9.3.3.2.3 Flood Control Alternative

The probability of Lake Mead pool elevation exceeding 1170 feet msl under the Flood Control Alternative is typically up to two percent greater than under baseline conditions. In the first 15 years of analysis, the probability decreases from 100 to 46 percent, and is within one percent of baseline conditions. Between years 16 and 22, the probability continues to decline, ranging between 47 and 39 percent, and is typically one percent greater than under baseline conditions. For the remainder of the analysis period, the probability is up to 4 percent greater than baseline conditions, ranging between 42 and 34 percent.

#### 3.9.3.3.2.4 Six States Alternative

The effects of the Six States Alternative would be nearly the same as those for the Basin States Alternative. In the first 15 years of the analysis period, the probability of Lake Mead elevation exceeding 1170 feet msl is typically up to 11 percent less than under baseline conditions. Between years 16 and 22, the probability stabilizes and converges with baseline conditions. The probability is typically within two percent of baseline conditions. For the remainder of the analysis period, the probability is within one percent of baseline conditions, ranging between 40 and 34 percent.

#### 3.9.3.3.2.5 California Alternative

The probability of Lake Mead pool elevation exceeding 1170 feet msl under the California Alternative is similar to that under the Shortage Protection Alternative and less than under baseline conditions and the other alternatives. In the first 15 years, the probability drops from 80 to 33 percent, then rises to 35 percent. The probability is up to 31 percent less than under baseline conditions. Between years 16 and 22, the probability rises slightly and converges with baseline conditions and the other alternatives. The probability ranges from eight percent less than to the same as under baseline conditions. For the remainder of the analysis period, the probability is within one percent of baseline conditions.

#### 3.9.3.3.2.6 Shortage Protection Alternative

The effects of the Shortage Protection Alternative are very similar to those described for the California Alternative. The probability of Lake Mead pool elevation exceeding 1170 feet msl is generally within one percent of the probability under the California Alternative throughout the period of analysis.

### 3.9.4 RIVER AND WHITEWATER BOATING

The Grand Canyon Protection Act directs the Secretary to operate Glen Canyon Dam in accordance with the additional criteria and operating plans specified in Section 1804 of the Act, and to exercise other authorities under existing law in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including but not limited to natural and cultural resources and visitor use.

The Glen Canyon Dam Adaptive Management Program (AMP) was established as a Federal Advisory Committee to assist the Secretary in implementing the Grand Canyon Protection Act. As discussed in Section 3.2.2, the AMP provides a process for assessing the effects of current operations of Glen Canyon Dam on downstream resources and using the results to develop recommendations for modifying operating criteria and other resource management actions. While the interim surplus criteria could have an influence on releases from Glen Canyon Dam, such releases will be governed by the criteria in the Record of Decision, which was developed in full consideration of both the safety and quality of recreational experiences in Glen and Grand Canyons. A summary of the Glen Canyon Dam Record of Decision has been included as Attachment D of this FEIS.

The only effect that implementation of the interim surplus criteria alternatives would have on whitewater boaters would be the possibility of lowered pool elevations in Lake Powell and Lake Mead. Whitewater boaters on the San Juan River often end their trips at Lake Powell. While decreased levels in Lake Powell have effects on take out points in the Colorado and San Juan Rivers, they also may expose additional rapids in Cataract Canyon, which would expand whitewater rafting opportunities. Section 3.9.3.2.1 discusses boaters entering Lake Powell.

Whitewater boaters on the Colorado River often end their trips in Lake Mead. Pearce Ferry is the preferred Lake Mead take out for boaters, but it may not be accessible when the reservoir pool elevation is below 1183 feet msl. An analysis of this elevation is presented in Section 3.9.2.2. A take out is also available at Diamond Creek, upstream of Lake Mead at the Hualapai Reservation. The Hualapai Tribe maintains the take out area and road and charges a fee for take out. The Hualapai Tribe also conducts river trips from Diamond Creek (on the Colorado River) to Pearce Ferry. This concession may be affected if trips encounter changes in availability of the Pearce Ferry take out.

### 3.9.5 SPORT FISHING

This section considers potential effects of the interim surplus criteria alternatives on recreational opportunities associated with sport fishing at Lake Powell, Lake Mead and Lake Mohave (between Hoover and Davis Dam). Sport fishing in the Colorado River between Glen Canyon Dam and Lake Mead will not be affected by the interim surplus criteria action due to the protection afforded by the Adaptive Management Program (see

Section 3.9.4). Fluctuations in flows between Hoover Dam and the SIB under the alternatives would be within the historical operating range of the river. Therefore, changes in flows under the alternatives would not affect recreation within these areas. Adverse effects on sport fisheries from potential changes in water temperature below Hoover Dam would not be expected, as discussed in Section 3.7.3.

### 3.9.5.1 METHODOLOGY

The discussion of the affected environment for reservoir fishing is based on a review of published documents. Much of this information was derived from the following sources: for Lake Powell, the *Fish Management Plan, Glen Canyon National Recreation Area* (NPS, 1996); and for Lake Mead, the *Desert Lake View Newspaper, Fall/Winter 1999*. In addition, creel information and angler fishing data has been obtained from state agencies in Utah, Arizona, and Nevada responsible for managing the fisheries resources at Lake Mead, Lake Powell, and Lake Mohave.

Assessment of potential impacts on sport fishing in Lake Powell, Lake Mead and Lake Mohave is based on information presented in other sections of the document regarding sport fishery populations (Section 3.7), reservoir shoreline facilities (Section 3.9.2) and reservoir navigation (Section 3.9.3). There were no specific reservoir pool elevation thresholds related to sport fishing identified from the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat discussed in Section 3.7, Aquatic Resources. Fishing satisfaction is assumed to be directly related to the general recreation issues of boating access to the water via shoreline facilities, and boating navigation potential for hazards or reservoir detours due to low pool elevations. As discussed in Section 3.7, catch rates are not expected to be affected by fluctuations in pool elevations.

### 3.9.5.2 AFFECTED ENVIRONMENT

#### 3.9.5.2.1 Sport Fishing in Lake Powell

As discussed in Sections 3.7 and 3.8, native Colorado River species have not done well in the reservoir environment. While some native species may spawn in the reservoir, it is believed that the majority of young are eliminated by sport fish predators. The predominant sport fishery in Lake Powell revolves around striped bass. The striped bass depend on threadfin shad as a food source, so it is critical to maintain a balanced shad population for the striped bass. The threadfin shad in Lake Powell are at the northernmost portion of their range and are very sensitive to fluctuations in water temperature. In addition to striped bass, Lake Powell supports largemouth and smallmouth bass, walleye, channel catfish, bluegill, and black crappie. Lake Powell has been stocked with fish almost annually, beginning in 1963 (NPS, 1996).

Lake Powell is a popular fishing destination. Over three million people visit the GCNRA annually, and those that fish spend a total of close to two million angler hours in pursuit of a variety of sport fish.

Nearly all anglers fish by boat due to the cliff-like canyon walls of the reservoir. Shore angling is rare. Annual angler use, based on boat fishing, is estimated to average 72,608 days. The majority of anglers (42 percent) come from Utah, followed by Colorado (24 percent) and Arizona (23 percent). California and other states make up the remaining 11 percent (Gustaveson, 2000).

Currently, the catch rate is 0.3 fish per hour, a number that has declined in recent years due to angling pressure. Approximately one-half of the fish caught are harvested, which results in an average annual harvest of 300,000 fish (NPS, 1996). Fishing catch rates and harvest rates differ at Lake Powell due to changing public attitudes towards catch and release. Most anglers release smallmouth bass and harvest striped bass. In 1997, 86 percent of the smallmouth bass caught were returned, compared to only 28 percent of the 396,000 striped bass caught (Gustaveson, 2000).

Most Lake Powell anglers seek a fishing opportunity and would rather catch any fish, compared to a targeted individual species. However, when asked for a species preference, most anglers prefer to catch black bass or striped bass. Most anglers tend to target species they expect to catch most readily. (Gustaveson, 2000).

Recent studies have indicated a trend of increasing biocontaminant concentration in aquatic organisms near the dam. Selenium has been found in plankton and in striped bass. Although there have not yet been any apparent negative impacts on striped bass reproduction, selenium can pose a health risk to anglers from consumption. If the presence of selenium continues, educating the anglers and performing risk assessment studies may be necessary (NPS, 1996).

#### 3.9.5.2.2 Sport Fishing in Lake Mead

Fishing is a favorite activity at Lake Mead. Largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill can be found in Lake Mead.

Lake Mead is famous for its striped bass, with an occasional catch weighing over 40 pounds, although weights of three to five pounds are more common. Angler survey results from NDOW indicate that since 1984, striped bass have been the species most sought after by anglers by a wide margin (62.7 percent) (NDOW, 2000). Fishing for striped bass or largemouth bass is good throughout the entire lake, but panfish and catfish are more prevalent in the upper Overton Arm.

The Nevada Division of Wildlife (NDOW) stocks rainbow trout from late December through the spring months. The razorback sucker, a protected fish species, must be returned to the water immediately and carefully, if caught. Fishing is generally better in the fall months of September, October and November. Larger fish are caught by deep water trolling in spring from March through May.

To fish from shore, a valid license is required from the state where the fishing occurs. If fishing from a boat or other flotation device, a use stamp from the other state is required. Rainbow trout fishing also requires an additional stamp. Children under 14 are not required to have a license.

The NDOW conducts annual creel and angler use surveys of Nevada licensed anglers (resident and non-resident). While Arizona licensed anglers also fish in Lake Mead, it is estimated that roughly 80 percent of the fishing use on the reservoir is represented in the NDOW surveys (Sjöberg, 2000). NDOW's annual statewide angler questionnaire is mailed out to 10 percent of all Nevada licensed anglers, resident and non-resident. Table 3.9-11 presents data from 10 years of questionnaires.

**Table 3.9-11**
**Nevada Division of Wildlife Annual Angler Questionnaire Results for Lake Mead**

| Year | Anglers | Angler Days | Fish Harvest (all species) | Days per Angler | Fish per Angler | Fish per Angler Day |
|---|---|---|---|---|---|---|
| 1989 | 44,444 | 476,543 | 940,608 | 10.72 | 21.16 | 1.97 |
| 1990 | 41,012 | 488,381 | 934,807 | 11.91 | 22.79 | 1.91 |
| 1991 | 47,873 | 792,883 | 1,532,481 | 16.56 | 32.01 | 1.93 |
| 1992 | 46,460 | 558,301 | 1,314,508 | 12.02 | 28.29 | 2.35 |
| 1993 | 46,649 | 697,117 | 1,699,816 | 14.94 | 36.44 | 2.44 |
| 1994 | 45,507 | 648,928 | 1,710,412 | 14.26 | 37.59 | 2.64 |
| 1995 | 47,630 | 574,972 | 1,590,413 | 12.07 | 33.39 | 2.77 |
| 1996 | 42,715 | 554,625 | 1,410,440 | 12.98 | 33.02 | 2.54 |
| 1997 | 43,747 | 505,892 | 1,239,840 | 11.56 | 28.34 | 2.45 |
| 1998 | 43,831 | 612,551 | 1,568,676 | 13.98 | 35.79 | 2.56 |
| Average | 44,987 | 591,019 | 1,394,200 | 13.10 | 30.88 | 2.36 |

Source: NDOW, Statewide Angler Questionnaire Database, 1989 through 1998, cover letter dated 5 October, 2000

The Arizona Department of Game and Fish estimated the Arizona licensed angler use for Lake Mead (based on Nevada survey results) to be 118,422 days in 1995. Combined with Nevada's use estimate for the same year, there were 693,394 angler days on Lake Mead in 1995 (83 percent from Nevada, and 17 percent from Arizona).

### 3.9.5.2.3 Sport Fishing in Lake Mohave

This section discusses sport fishing in Lake Mohave, below Hoover Dam. Table 3.9-12 shows the developed access sites and facilities at Lake Mohave.

**Table 3.9-12**
**Lake Mohave Developed Recreation Facilities**

| Facilities | Willow Beach | Cottonwood Cove | Katherine |
|---|---|---|---|
| Ranger Station | • | • | • |
| Lodging | N/A | • | • |
| Trailer Village (fee) | N/A | • | • |
| Campground | N/A | • | • |
| Marina | • | • | • |
| Food Service | • | • | • |
| Grocery/Gift Shop | • | • | • |
| Gasoline | • | • | • |
| Picnic Area | • | • | • |
| Shower (fee) | N/A | • | • |
| Trailer Sewage Dump | • | • | • |
| Boat Sewage Dump | • | • | • |
| Self-service laundry | N/A | • | • |
| Propane Service | • | • | • |
| Houseboat Rentals | N/A | • | • |

Source: NPS, 1995.
• indicates presence of improvement
N/A indicates no improvement

In Lake Mohave there are largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie and bluegill. Because Lake Mohave is within the LMNRA, the same fishing rules and requirements described above for Lake Mead apply to Lake Mohave. NDOW stocks rainbow trout in the lake from late December through the spring months. The USFWS stocks rainbow trout throughout the year, with concentrated stocking October through May.

Three protected species, including razorback sucker, Colorado squawfish, and bonytail chub, are the last of the native Colorado River fish and can be found in Lake Mohave.

When caught, these fish must be released. Fishing is open year round, but the best fishing generally occurs in September, October and November. For deep water trolling, March through May is best.

Fishing on Lake Mohave can be exceptional. Bass and trout often run three pounds, with some trout weighing as much as 10 or more pounds. Anglers fish for big trout at Willow Beach, while Cottonwood Cove and Katherine Landing offer both bass and trout fishing. Within the last few years, striped bass fishing has become very popular.

The NDOW conducts annual creel surveys at Cottonwood Cove and Willow Beach. In 1998, angler use for Lake Mohave was estimated at 155,654 angler days, about the same as in 1997. The 1998 lake-wide harvest was estimated at 414,954 fish. Of the species caught, 80 percent were striped bass and 12 percent were rainbow trout. Other species included largemouth bass, channel catfish, and sunfish.

### 3.9.5.3 Environmental Consequences

#### 3.9.5.3.1 Sport Fishing in Lake Powell, Lake Mead and Lake Mohave

Reduced reservoir surface elevations could affect recreational reservoir fishing by decreasing the number of fishing days and angler satisfaction. The lower pool elevations could cause temporary or permanent closure or relocation of shoreline facilities, thus requiring the boat angler to either travel to another launch site, fish from the bank, or possibly forego fishing that day. Also, navigational issues, such as the closure of areas of the reservoirs, could increase travel times to desired fishing locations and result in reduced angler satisfaction. Lower pool elevations may make some shoreline fishing areas inaccessible. In addition, as discussed in Section 3.9.3.2, as pool elevations lower, the surface area available for boats and safe boat capacity decreases. The boat angler may need to call ahead for reservoir conditions. Lake Mohave surface elevations will not be affected by any of the alternatives.

No direct information on angler success rates or angler satisfaction in relationship to reservoir pool elevations is available. Therefore, potential effects were determined indirectly through consideration of potential effects on sport fishery production and water access for boat and shore anglers. The effects of the alternatives on sports fishery production are discussed in detail in Section 3.7.4 The effects on boating access, including shoreline facilities that provide access to the water for boat angling and navigational constraints on boating, are discussed in Sections 3.9.2 and 3.9.3.

As discussed in Section 3.7.4, Sport Fisheries, potential reductions in surface elevations associated with the interim surplus criteria alternatives are not expected to affect sport fishery composition or quantities within the reservoirs. As such, angler success rates at Lake Powell and Lake Mead would not be reduced.

## 3.9.6 RECREATIONAL FACILITIES OPERATIONAL COSTS

In order to keep reservoir marinas, boat launching, public use beaches and shoreline access operational, facility owners/operators and agencies providing utility connections must respond to fluctuating pool elevations. This section focuses on the operational and capital costs of keeping recreational facilities in operation as reservoir surface elevations change.

Potential revenue effects from changes in recreation use are not considered. As discussed above, it is not expected that baseline conditions or interim surplus criteria would result in facility closures, as most facilities can be relocated to maintain operation at lower reservoir elevations.

### 3.9.6.1 METHODOLOGY

Information in the affected environment section was compiled after review of available published and unpublished sources and through personal communication with NPS specialists. Available data do not cover all facilities. Furthermore, the analysis is generally based on professional judgment, extrapolating from limited historical data. However, the analysis provides a useful approximation of the order of magnitude of costs to recreational facilities that may be incurred under projections for each of the alternatives.

Using data associated with facility relocation costs, projections of the costs associated with declines were made using results of the river system modeling discussed in Section 3.3. Calculations of potential costs use model projections associated with the 50 percent exceedence probability elevations for years 2002 through 2016. This simplified methodology addresses multi-year changes in elevation, and does not consider costs associated with facility adjustments to accommodate monthly fluctuations.

### 3.9.6.2 AFFECTED ENVIRONMENT

The following sections discuss costs associated with relocation of reservoir marinas and boat launching facilities at Lake Powell and Lake Mead. Many of the facilities at Lake Powell and Lake Mead were constructed when the reservoirs were near their maximum pool elevations of 3700 feet msl and 1210 feet msl, respectively.

#### 3.9.6.2.1 Lake Powell

The costs of fluctuating pool elevations on Lake Powell marinas and boat-launching facilities were calculated by Combrink and Collins (1992). The study calculated operating costs for one-foot fluctuations (termed "normal adjustments") and for adjustments when the pool fluctuation exceeds 25 feet (termed "special adjustments"). The normal adjustments are adjustments made within the range of regular operations and are done routinely as water levels change during the year. Special adjustments include relocations of anchors and extensions of cables and utilities. The study found that major capital investments would be needed; cost estimates were developed based on a 50-foot decline in pool elevations.

Additional data for the Antelope Point Marina has been provided by the Navajo Nation and National Park Service. Construction drawings have been prepared to allow extension of the ramp from 3677 to 3620 feet msl, with a reported capital cost estimate of approximately $500,000 (Bishop, Personal Communication, 2000). This cost has been included in NPS planning for Antelope Point.

Table 3.9-13 presents the costs incurred per adjustment in the form that the data was collected. In order to use the data to compare different alternatives, it has been converted into a cost per foot of fluctuation. Data collected in 1989 has been updated to 2000 price levels.

**Table 3.9-13**
**Costs Associated with Adjustments to Lake Powell Recreation Facilities**

| Adjustment Cost Category[1] | Cost per Adjustment: 1989 Price Level [2] | Cost per Adjustment: 2000 Price Level [3] | Cost per Foot |
|---|---|---|---|
| Operating Cost for a Normal Adjustment (based on one-foot fluctuation) | $1,275 | $1,721 | $1,721 |
| Operating Cost for a Special Adjustment (fluctuations exceeding 25 feet) | $33,460 | $45,171 | $1,807 |
| Capital Cost for each 50-foot drop | $2,000,000 | $2,700,000 | $54,000 |
| **Total Cost per Foot** | | | **$57,528** |
| Additional Capital Cost for drop below 3677 water surface elevation[4] | | $500,000 | |

[1] Operating costs are the cost of adjusting the existing facilities for fluctuations and consist of labor hours. Capital costs consist of construction of ramp extensions, utility line extensions and relocations.
[2] Combrink and Collins (1992).
[3] Consumer Price Index-All Urban Consumers. 1989 average is 124.0. March 2000 is 167.8. Adjustment factor: 167.8/124.0 = 1.35
[4] Capital cost to extend the toe of the existing Antelope Point Marina from 3677 to 3620 feet msl (Bishop, Personal Communication, 2000).

Table 3.9-13 indicates there are costs associated with even minor changes in pool elevations. However, the cost of capital improvements required to extend utilities and access below the range of elevations that can be accommodated by existing infrastructure is much larger than the operating costs incurred within the capacity of the existing infrastructure.

It should be noted that many of the Lake Powell shoreline facilities were extended in 1992/93 to accommodate reduced Lake Powell surface elevation down to 3612 feet msl. Due to these extensions, the actual costs of relocating facilities in the event of future

Lake Powell surface elevation declines may be lower than those indicated in the analysis.

### 3.9.6.2.2 Lake Mead

NPS provided information on costs associated with relocation of facilities at Lake Mead. The operating levels range between full pool elevation (1210 feet msl) and 1180 feet msl. When Lake Mead declines to 1180 feet msl, adjustments need to be made to the major facilities. Costs to make these adjustments for each of the major facilities at year 2000 price levels range from $560,000 to $970,000. NPS has also determined that additional incremental drops of 20 feet in elevation will incur additional costs, ranging from $480,000 to $800,000 (Henderson, 2000).

Costs associated with fluctuating pool elevations are available for federally-owned facilities at LMNRA from unpublished data assembled by the Resource Management Office, Lake Mead NRA (Henderson, Burke and Vanderford, April 17 and 18, 2000). In addition, Overton Beach Marina (letter dated March 29, 2000) and Lake Mead Resort (letter dated April 11, 2000) provided information to Reclamation indicating the costs associated with fluctuating reservoir elevations. Table 3.9-14 presents these costs.

**Table 3.9-14**
**Costs Incurred to Recreational Facilities from Lake Mead Pool Fluctuations**
**(Year 2000 Price Level)**

| Line No. | Fluctuation | Cost per Increment |
|---|---|---|
| 1 | Cost to LMNRA facilities of surface elevation occurrence below 1180 feet msl [1] | $ 6,011,000 |
| 2 | Cost to LMNRA facilities at 1160 feet msl and at each additional 20-foot drop [1] | $ 5,080,000 |
| 3 | Cost to Lake Mead Resort Marina from a 20-foot drop in elevation [2] | $ 91,400 |
| 4 | Cost to Overton Beach Marina facilities from a fluctuation from 1212 feet msl to 1150 feet msl (62 feet) [3] | $ 60,000 |
| 5 | Cost to Overton Beach Marina Facilities from a fluctuation from 1150 feet msl to 1130 feet msl (20 feet) [3] | $ 425,000 |
| 6 | Cost to Temple Bar Resort from a 10-foot drop [4] | $ 12,500 |
| 7 | Cost to Echo Bay Resort from a 20-foot drop from 1213 feet msl to 1193 feet msl [5] | $ 38,400 |

[1] Unpublished data from Lake Mead NRA.
[2] Letter dated April 11, 2000. from Lake Mead Resort to Reclamation The letter quantifies cost for a drop from current pool elevations. It also notes that a drop below 1150 would, in the NPS's judgement. require abandonment of the basin within which the resort is located.
[3] Letter dated March 29, 2000. from Overton Beach Marina to Reclamation.
[4] Letter dated March 27, 2000, from Temple Bar Resort. Midpoint of range ($10.000 to $15,000) is used. Letter further notes that a drop below 1125 feet msl would require a complete relocation of the marina, including buildings located on land.
[5] Letter dated March 16, 2000, from Echo Bay Resort to Reclamation.

### 3.9.6.3 ENVIRONMENTAL CONSEQUENCES

#### 3.9.6.3.1 Lake Powell

As discussed in the methodology section, an estimate can be made of the cost impacts of the alternatives on Lake Powell recreational facilities under some basic conditions. Estimates in this section are for aggregate relocation costs associated with all identified Lake Powell shoreline facilities.

Table 3.9-15 shows estimated incremental costs that would be incurred from Lake Powell surface elevation decreases associated with the median elevation projections for baseline conditions and each alternative from 2002 through 2016 (Figure 3.9-1 presents these elevations graphically). These impacts are based on a cost of $57,528 per foot change in elevation, developed based on the information shown in Table 3.9-12.

**Table 3.9-15**
**Costs Associated with Potential Relocation of Lake Powell Recreational Facilities Under Alternatives Compared to Baseline Conditions[1]**
**(Year 2000 Price Level)**

| Alternative | Median Elevation in Year 2016 (feet msl)[2] | Elevation Below Baseline Conditions (feet) | Incremental Cost during 15-Year Period[3] |
|---|---|---|---|
| Baseline Conditions | 3665 | 0 | --------- |
| Basin States Alternative | 3664 | 1 | $ 747,864 |
| Flood Control Alternative | 3665 | 0 | $ 0 |
| Six States Alternative | 3664 | 1 | $ 747,864 |
| California Alternative | 3660 | 5 | $1,208,088 |
| Shortage Protection Alternative | 3659 | 6 | $1,438,200 |

[1] Assumes pool elevation decreases constantly over time, following 50% probability of exceedence elevation.
[2] Based on 50 percent probability of exceedence elevation projected from modeling on July 31 of each year.
[3] Table 3.9-13. $57,528 per foot for each facility. No incremental cost is included for extending the ramp at the Antelope Point Marina.

By 2050, the median elevation of all alternatives is within a two-foot range (3662.5 to 3664.6) and the difference in costs is small.

#### 3.9.6.3.2 Lake Mead

As discussed in the methodology section, an estimate can be made of the cost impact of the alternatives on Lake Mead recreational facilities using certain assumptions.

Table 3.9-16 shows estimated incremental costs that would be incurred from Lake Mead surface elevation decreases associated with the median elevation projections for each alternative as compared to baseline conditions from 2002 through 2016 (Figure 3.9-4 presents the median elevations graphically).

**Table 3.9-16**
**Costs Associated with Potential Relocation of Lake Mead Recreational Facilities Under Alternatives Compared to Baseline Conditions[1]**

| Alternative | Elevation in Year 2016 (feet msl)[2] | Elevation Below Baseline Conditions | Incremental Cost during 15-Year Period |
|---|---|---|---|
| Baseline Conditions | 1162 | N/A | NA |
| Basin States Alternative | 1143 | 19 | $ 5,243,900[3] |
| Flood Control Alternative | 1162 | 0 | 0 |
| Six States Alternative | 1146 | 16 | $ 5,243,900[3] |
| California Alternative | 1131 | 31 | $ 10,348,900[4] |
| Shortage Protection Alternative | 1130 | 32 | $ 10,773,900[5] |

1 Assumes pool elevation decreases constantly over time, following 50% probability of exceedence elevation.
2 Based on 50 percent probability of exceedence elevation on December 31 of each year projected from river system modeling.
3 Lines 2, 3, 4 and 6 from Table 3.9-14.
4 Two times Line 2, one times Line 3 and 4, and three times Line 6 from Table 3.9-14.
5 Two times Line 2, one times Lines 3, 4 and 5, and three times Line 6 from Table 3.9-14

By 2050, the median elevation under all alternatives is the same (1110.6 feet msl), and no differences in cost would occur.

# 3.10 ENERGY RESOURCES

## 3.10.1 INTRODUCTION

The analyses in this section consider two specific issues associated with energy resources. The first issue considered is potential changes in hydropower production from Hoover Dam and Glen Canyon Dam; the second is potential increases in energy requirements of the Southern Nevada Water System (SNWS) Lake Mead intake, Navajo Generating Station cooling water intake in Lake Powell and the City of Page potable water intake in Lake Powell.

## 3.10.2 HYDROPOWER

This section discusses potential changes in power production that could occur as a result of the interim surplus criteria under consideration. The analysis focuses on changes in production from Glen Canyon Dam and Hoover Dam for each alternative compared to baseline conditions.

### 3.10.2.1 METHODOLOGY

In order to determine the effects of the interim surplus criteria alternatives, the information produced from the river system modeling described in detail in Section 3.3 has been used. This model simulates operation of Glen Canyon and Hoover powerplants under baseline conditions and the interim surplus criteria alternatives. The output quantities of the model that are important in determining the effects of the alternatives on power generation are:

- Annual average Lake Powell Elevation;
- Annual average Glen Canyon Powerplant Energy Production;
- Annual average Lake Mead Elevation;
- Annual average Hoover Powerplant Energy Production;
- Annual average Lake Mohave Elevation (constant at an elevation of 647 feet msl throughout the period of analysis).

These quantities, derived from the model runs, are shown in Tables 1, 2, 5 and 7 in Attachment P. In addition, powerplant capability curves for Glen Canyon and Hoover powerplants showing powerplant capacity as a function of lake elevation (or net effective head) are required to determine how the capacity varies for each alternative throughout the study period. Powerplant capability curves used for the analysis are presented in Tables 3 and 4 in Attachment P.

Table 3 of Attachment P uses discharge multipliers to determine the maximum operable capacity of the Glen Canyon Powerplant. The maximum water release of 25,000 cfs (restricted except during power system emergencies) is divided by the discharge multiplier to calculate the capacity. Table 4, for Hoover Powerplant, uses the theoretical turbine curve data for heads from 560 feet to 590 feet. Below 560 feet of head, a ratio of 2062/2074 has been applied to the turbine curve data to reflect recent downratings of units A3, A4, and A8 as reported in a letter dated July 2000, from the Area Manager of Reclamation to Western.

As used herein, powerplant capacity refers to the load that a generator or facility can achieve at a given moment. Energy is a measure of electric capacity generated over time. Comparing the projected amount of powerplant generating capacity and energy production available under the various alternatives with baseline projections produces a probabilistic measure of the effects of the alternatives on power production if the assumptions contained in the forecasts covering water supply materialize.

The methodology for determination of the effects of the alternatives is to compare the change in capacity and energy production, on an annual basis, between baseline conditions and each alternative. Annual average generating capacity and energy available from Glen Canyon and Hoover powerplants was determined using the reservoir elevation and energy output quantities from system modeling discussed in Section 3.3, and the powerplant capability curves. Modeling of energy production is based on aggregate turbine production curves. Annual average capacity and energy production for baseline conditions and the alternatives are shown in Tables 5 and 7 in Attachment P. Annual average energy production is also shown in Figures 3.10-1 and 3.10-2. Comparisons of the annual average energy production associated with each alternative and the annual average energy production of baseline conditions are shown in Tables 6 and 8 in Attachment P.

### 3.10.2.2 AFFECTED ENVIRONMENT

The energy resources that could be affected by changes in Colorado River operation are Glen Canyon Powerplant and Hoover Powerplant electrical power output. The reservoirs behind these facilities are operated to store Colorado River water for delivery in the Lower Colorado River Basin below Glen Canyon Dam, and water to meet delivery obligations to Arizona, California, Nevada and Mexico downstream of Hoover Dam.

#### 3.10.2.2.1 Factors of Power Production

In general, the two factors of a hydroelectric system, excluding machinery capability, that are directly related to power production are the net effective head on the generating units, and the quantity of water flowing through the turbines.

The net effective head is the difference between the water surface elevations of the forebay behind a dam and in the tailwater below the dam. The head determines the maximum capacity, measured in MW, that is available from the powerplant. The nameplate capacity of Glen Canyon Powerplant is 1296 MW. However, the maximum operating capacity of Glen Canyon Powerplant generators is approximately 1200 MW due to turbine restrictions (Western, 1998). Because the maximum allowable water release has been limited to 25,000 cfs, the maximum operable capacity for Glen Canyon is limited to 1048 MW, except during a power system emergency. The maximum operating capacity of Hoover Powerplant is 2074 MW. The net effective head on the powerplant is influenced by the reservoir surface elevations and operating strategies for both the upstream and downstream reservoirs.

The quantity of water flowing through the turbines (water releases) determines the amount of energy produced, measured in gigawatt-hours (GWh). The net energy generated during fiscal year 1998 from Glen Canyon Powerplant and Hoover Powerplant was 6626 GWh and 5768 GWh, respectively (Western, 1998 and Reclamation, 2000).

The turbines at a powerplant are designed to produce maximum efficiency at a design head. At design head, the plant can produce the maximum capacity and the most energy per acre-foot of water passing through the turbine. As the net effective head on the powerplant is reduced from design head because of reduced forebay (upstream reservoir) elevation, the power output of the turbine is reduced, the electrical capacity of the generator attached to the turbine is reduced, and the efficiency of the turbine is reduced. This reduction continues as net effective head decreases until, below the minimum elevation for power generation, the turbines cannot be operated safely and must be bypassed for downstream water deliveries. Minimum power elevation generally occurs at a point where cavitation within the turbine causes extremely rough operation, air may become entrained in the water, and/or vortices may appear in the forebay.

#### 3.10.2.2.2 Power Marketing and Customers

The effects of any surplus or deficit in power generation are incurred by the customers to whom the power from Glen Canyon and Hoover powerplants is allocated. The contracts for power from Glen Canyon Dam terminate in 2025. The contracts for power from Hoover Dam terminate in 2017. The identity of the recipients of power from these resources is not known for about two-thirds of the period of analysis for Hoover Dam and about one-half of the period of analysis for Glen Canyon Dam. Therefore, an analysis of the effects of the alternatives compared with those of baseline conditions will consider the general effects in the overall areas served by the resources, although a future group of power customers would be impacted similarly to current customers.

The states that would be affected by changes in energy and capacity at Glen Canyon and Hoover powerplants are Arizona, California, Nevada, Utah, Wyoming, New

Mexico and Colorado. These states make up the Rocky Mountain, Arizona-New Mexico-Southern Nevada, and California-Mexico areas of the Western Systems Coordinating Council (WSCC). Electrical energy produced in each of these areas is derived from a variety of sources. The power from Glen Canyon Powerplant and Hoover Powerplant contributes a small, but significant portion of the energy produced in these areas. The total generation capability of the areas as of January 1, 1999, is 86,348 MW. The generation capability of each WSCC area is:

- Rocky Mountain 10,584 MW
- Arizona-New Mexico-Southern Nevada 22,272 MW
- California-Mexico 53,492 MW

Glen Canyon and Hoover powerplants contribute approximately 3.6 percent of the total generating capability of these three areas of WSCC (WSCC, 1999). The maximum capacity available from Glen Canyon Powerplant at elevation 3700 feet msl has been restricted to approximately 1200 MW. However, as stated above, the maximum operable capacity at Glen Canyon Powerplant is limited to 1048 MW due to water release restrictions, except during power system emergencies. Therefore, for the purposes of this analysis, the operable capacities of Hoover and Glen Canyon powerplants are 2074 MW and 1048 MW, respectively, for a total of 3122 MW.

### 3.10.2.3 ENVIRONMENTAL CONSEQUENCES

The environmental consequences of a change in river operations that impacts power production can be measured by the increase or decrease in capacity and energy available from the powerplants. The power production under the alternatives is compared with power production under baseline conditions to determine the incremental effects of each alternative, using annual average modeled reservoir levels and downstream releases. Reductions in capacity, energy, and generation ancillary services from Glen Canyon and Hoover powerplants under baseline conditions would ultimately need to be replaced by either types of generation. Additional incremental reductions under each alternative would also ultimately need to be replaced.

The replacement of Glen Canyon and Hoover powerplant generation could be accomplished through a number of different strategies. If capacity loss can be expected for long periods of time, construction of new generation would likely occur. If capacity loss is intermittent throughout the period of analysis, purchases from the short-term market would be expected. If energy loss can be expected for a long period of time, either construction of new generation or operation of higher-cost generation for longer periods of time during the day would be expected. If energy loss is intermittent throughout the period of analysis, replacement from the short-term market would be anticipated.

### 3.10.2.3.1 Baseline Conditions

#### 3.10.2.3.1.1 Glen Canyon Dam

The annual average capacity and energy production at Glen Canyon Dam under baseline projections are shown in Table 5 in Attachment P; the annual average energy production is shown in Figure 3.10-1. The powerplant capacity begins at 1020 MW in 2002 and is reduced to 960 MW in 2016 because of reductions in lake elevation. Subsequently, the capacity increases to 990 MW in 2041, then decreases to 975 MW in 2050. From 2002 through 2016, the greatest annual decrease in capacity is 13 MW between 2012 and 2013. The annual reduction throughout the early years is from two to six MW, representing less than a one percent decline in capacity from the powerplant per year. The output varies cyclically between 2017 and 2050, with annual increases or decreases in capacity of two to six MW.

Under baseline conditions, the energy available from Glen Canyon Dam averages 4532 GWh from 2002 through 2016, and 4086 GWh through the rest of the period of analysis. Energy production increases the first year of the study. Thereafter, annual reductions in energy production are generally less than 50 GWh per year through 2016. Annual reductions in energy from 2017 through 2050 are generally less than 40 GWh.

#### 3.10.2.3.1.2 Hoover Dam

The annual capacity and energy production at Hoover Powerplant under baseline conditions are shown in Table 7 of Attachment P; the annual average energy production is shown in Figure 3.10-2. The powerplant capacity begins at 2062 MW in 2002 and is reduced to 2033 MW in 2016 because of reductions in lake elevation. Capacity decreases to 1865 MW in the year 2050. From 2002 through 2016, the greatest annual decrease in capacity is nine MW. This reduction represents less than a one percent per year decline in capacity from the powerplant through 2016. From 2017 through the remainder of the period of analysis, the annual capacity reductions are generally less than 10 MW.

The energy available from Hoover Powerplant averages 4685 GWh from 2002 through 2016, and 3903 GWh through the rest of the period of analysis. Energy production increases during the first three years of the period of analysis, with annual reductions from 2004 through 2016 of generally less than 50 GWh. Annual reductions in energy from 2017 through 2050 are predominantly less than 60 GWh.

**Figure 3.10-1**
**Glen Canyon Powerplant**
**Annual Average Energy Production**

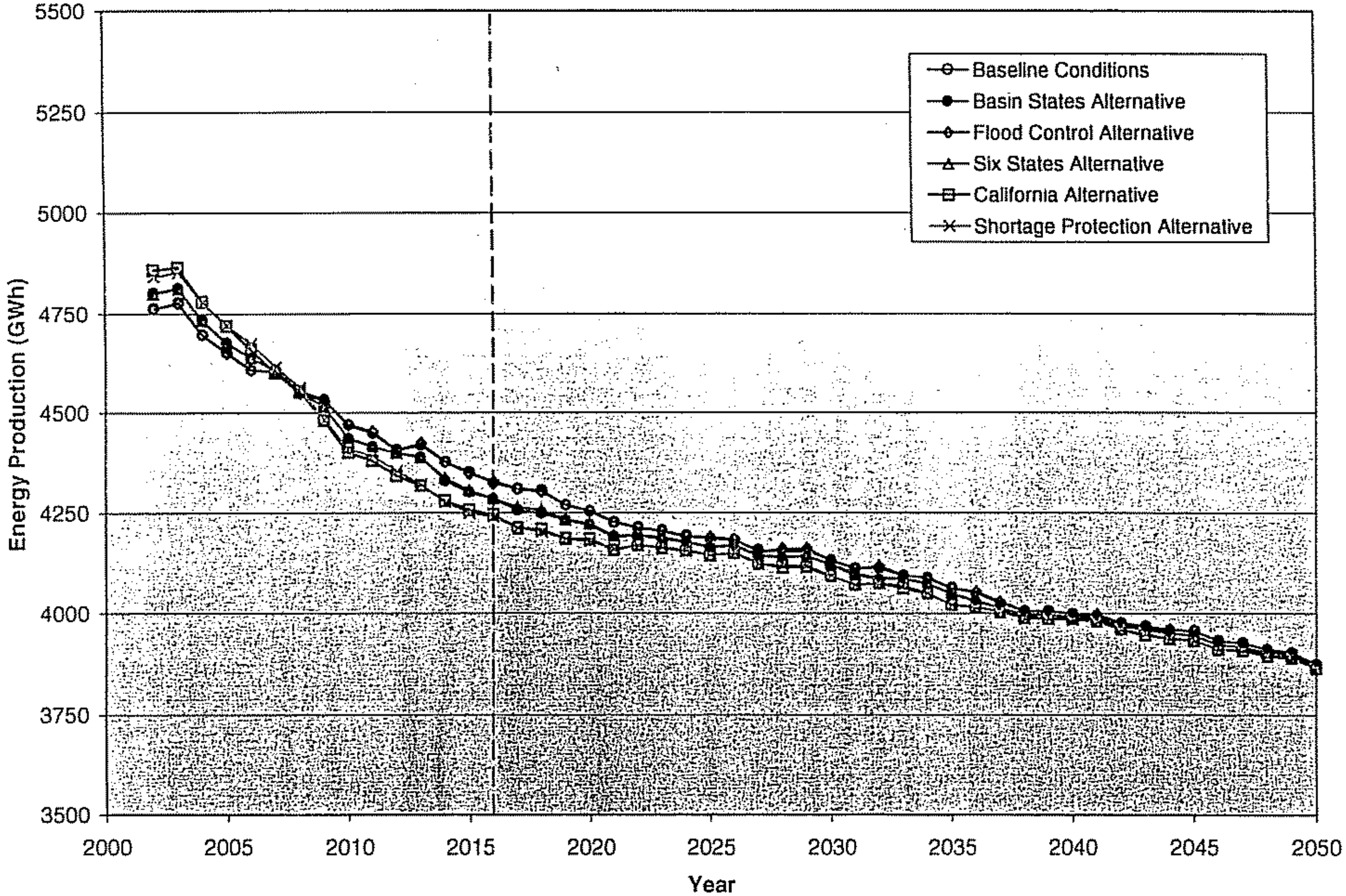
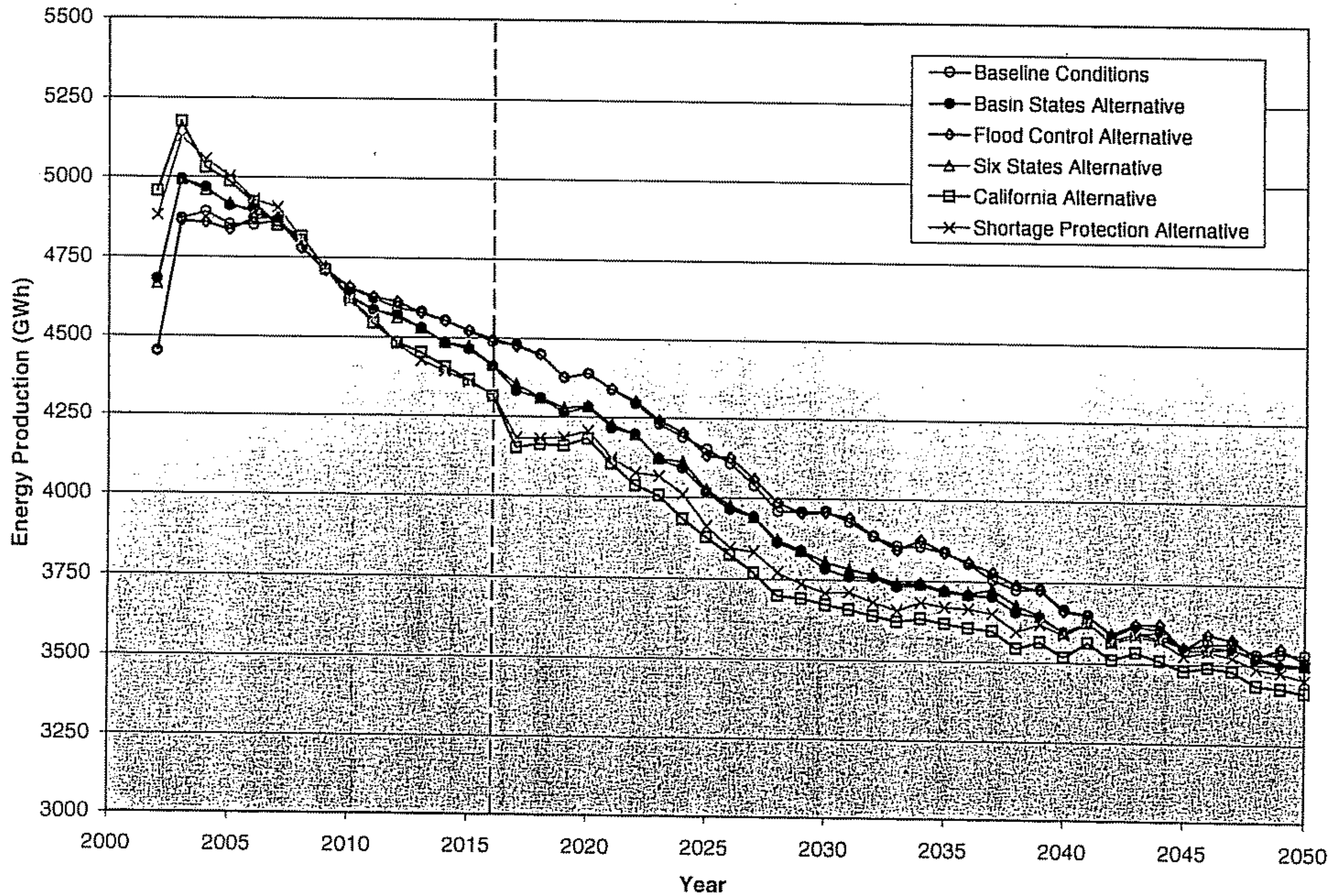


**Figure 3.10-2**
**Hoover Powerplant**
**Annual Average Energy Production**



#### 3.10.2.3.1.3 Combined Capacity and Energy Reduction Under Baseline Conditions

The combined capacity reduction from Glen Canyon and Hoover powerplants through 2016 is 89 MW under baseline conditions. The combined energy production in 2016 is 403 GWh less than year 2002 energy production. In 2050, the capacity reduction is 242 MW less than 2002 levels, and the energy available is reduced 1807 GWh from year 2002 production. Under baseline conditions, power customers can expect a reduction in production from present levels in the future. Because of the gradual withdrawal over time, the deficit is expected to be replaced by short-term purchases made by either the power customers or Western, at the power customer's option, in accordance with contract terms.

### 3.10.2.3.2 Basin States Alternative

#### 3.10.2.3.2.1 Glen Canyon Dam

The average capacity available from Glen Canyon Powerplant under the Basin States Alternative is shown in Table 5 of Attachment P. The powerplant capacity begins at 1014 MW in 2002 and is reduced to 960 MW in 2016. The capacity varies two to four MW each year until 2050, at which time powerplant capacity is at 975 MW. The average annual capacity available through the period of analysis is 987 MW.

The annual energy available averages 4527 GWh in the early years through 2016, and 4209 GWh throughout the period of analysis. Annual energy production in 2050 is 3875 GWh.

#### 3.10.2.3.2.2 Hoover Dam

The average capacity available from Hoover Powerplant is shown in Table 7 of Attachment P. The powerplant capacity begins at 2061 MW in 2002 and is reduced to 1971 MW in 2016. The capacity either increases or decreases in consecutive years by up to 44 MW, with the capacity in 2050 being 1865 MW. The average capacity available throughout the period of analysis is 1935 MW.

The average annual energy available is 4701 GWh through 2016, and 4087 GWh throughout the period of analysis. Annual energy production in 2050 is 3496 GWh.

### 3.10.2.3.3 Flood Control Alternative

#### 3.10.2.3.3.1 Glen Canyon Dam

The average capacity and energy available from Glen Canyon Powerplant under the Flood Control Alternative are shown in Table 5 of Attachment P. The powerplant capacity begins at 1020 MW in 2002 and is reduced to 962 MW in 2016. The decline continues to 975 MW in the year 2050. From 2002 through 2016, the greatest annual decrease in capacity is 12 MW. This reduction represents less than a one percent average decline in powerplant capacity per year through 2016. The capacity either increases or decreases in consecutive years through the remainder of the period of analysis. Capacity changes from the period 2016 through 2050 are predominantly in the two to six MW range each year, either increasing or decreasing.

Annual energy production from Glen Canyon averages 4532 GWh in the early years through 2016 and averages 4223 GWh throughout the period of analysis. Annual energy production in 2050 is 3875 GWh.

#### 3.10.2.3.3.2 Hoover Dam

The annual capacity and energy available from Hoover Powerplant under the Flood Control Alternative are shown in Table 7 of Attachment P. The powerplant capacity begins at 2062 MW in 2002 and is reduced to 2033 MW in 2016. Powerplant capacity continues on a declining trend, until the capacity reaches 1865 MW in 2050. The greatest declines in the period from 2002 through 2016 are five and 13 MW, with the annual decline in capacity being predominantly one to two MW.

Under the Flood Control Alternative, the annual energy available from Hoover Powerplant averages 4686 GWh during the period 2002 through 2016. The average for the period from 2017 through 2050 is 3908 GWh. The average for the entire study period is 4146 GWh.

### 3.10.2.3.4 Six States Alternative

#### 3.10.2.3.4.1 Glen Canyon Dam

The capacity available from Glen Canyon Powerplant under the Six States Alternative begins at 1014 MW in 2002 and decreases to 960 MW in 2016. The capacity then follows a generally increasing trend through 2043, after which annual reductions lead to a capacity of 975 MW in 2050. The capacity available averages 980 MW throughout the period of analysis. Annual changes of between two and five MW are predominant in the Six States Alternative.

The annual energy production averages 4527 GWh through 2016, and 4211 GWh throughout the period of analysis. Annual energy reductions throughout the period of analysis are predominantly less than 50 GWh.

#### 3.10.2.3.4.2 Hoover Dam

The capacity available from Hoover Powerplant under the Six States Alternative begins at 2061 MW in 2002 and decreases to 2005 MW in 2016. The capacity then follows a decreasing trend until the output reaches 1865 MW in 2050. The predominant annual capacity reductions throughout the study period are less than 10 MW.

The average annual energy production is 4698 GWh through 2016. The average annual energy production throughout the period of analysis is 4091 GWh. Annual energy production reductions in successive years are predominantly less than 50 GWh.

#### 3.10.2.3.5 California Alternative

##### 3.10.2.3.5.1 Glen Canyon Dam

The capacity available from Glen Canyon Powerplant under the California Alternative begins at 1007 MW in year 2002, and is reduced to 958 MW in 2016. The capacity follows a generally increasing trend from 2016 through the end of the period of analysis. In 2050, the capacity is 975 MW. Annual changes in plant capacity are generally between two and five megawatts.

Energy production at Glen Canyon averages 4516 GWh through 2016, and 4193 GWh throughout the entire period of analysis. Annual changes in energy production are generally less than 30 GWh.

##### 3.10.2.3.5.2 Hoover Dam

The capacity available from Hoover Powerplant under the California Alternative begins at 2061 MW in year 2002, and is reduced to 1907 MW in 2016. The capacity follows a generally downward trend from 2016 through the end of the period of analysis. In 2050, the capacity of Hoover is 1867 MW. Annual changes in plant capacity are generally less than 10 megawatts.

Annual energy production at Hoover averages 4709 GWh through 2016, and 4016 GWh throughout the period of analysis. Annual changes in energy production are predominantly less than 20 GWh.

#### 3.10.2.3.6 Shortage Protection Alternative

##### 3.10.2.3.6.1 Glen Canyon Dam

The capacity available from Glen Canyon Powerplant under the Shortage Protection Alternative begins at 1009 MW in 2002 and is reduced to 958 MW in the year 2016. The capacity generally increases to 988 MW in the early 2040s, then is reduced to 975 MW in the year 2050. Annual capacity variations are generally from two to six megawatts.

Energy production averages 4518 GWh through 2016, and 4193 GWh throughout the entire study period. Annual energy production variations are generally less than 30 GWh.

#### 3.10.2.3.6.2 Hoover Dam

The capacity available from Hoover Powerplant under the Shortage Protection Alternative begins at 2061 MW in 2002 and is reduced to 1904 MW in 2016. The capacity follows a generally decreasing trend from 2016 through 2050, when the capacity reaches 1865 MW. Annual capacity reductions are predominantly in the two to five megawatt range.

Annual energy production averages 4733 GWh from the beginning of the period of analysis to 2016, and 4047 GWh throughout the entire period of analysis. Annual variation throughout the period of analysis is generally less than 100 GWh.

### 3.10.2.4 COMPARISON OF ALTERNATIVES

As discussed above, the amounts of capacity and energy available as a result of each alternative operating strategy vary on an annual basis. The important measurement of the effects of each alternative is their comparison with the baseline conditions. As indicated, the resources available from Glen Canyon and Hoover powerplants can be expected to be reduced over time, due primarily to increased depletions in the Upper Basin states. This effect is included in model runs for baseline conditions.

Table 3.10-1 summarizes the differences between hydropower capacity and energy generation under each alternative and under baseline conditions. Values under the Flood Control Alternative are typically slightly greater than under baseline conditions. Values under the California and Shortage Protection Alternatives are the furthest from baseline conditions, while values under the Six States and Basin States alternatives are closer to baseline conditions.

The capacity and energy differences (reductions) between each alternative and baseline conditions would be replaced by power available from the market. The greatest single-year difference in energy generation at Glen Canyon Powerplant under any of the alternatives as compared to baseline conditions is 102 GWh, under the California and Shortage Protection Alternatives (see Table 6 of Attachment P) or about 2.5 percent of the modeled average annual generation of Glen Canyon. The effects of interim surplus alternatives are greater at Hoover Powerplant. The greatest single-year difference in annual energy generation under any of the alternatives as compared to baseline conditions is 328 GWh under the California Alternative (see Table 8 of Attachment P), or about eight percent of the modeled average annual energy generation. The average annual generation during the period of analysis under the Preferred (Basin States) Alternative is 0.8 percent (0.3 percent at Glen Canyon and 1.3 percent at Hoover) less than under baseline conditions. The quantities of capacity needed to replace reductions, while not significant when compared to the total capacity installed in the three WSCC regions, may be significant to the entity losing the capacity.

**Table 3.10-1**
**Hydropower Capacity and Energy – Comparison of Alternatives to Baseline Conditions[1]**
**(Difference between baseline conditions and each alternative[2])**

| Alternative | 2002 – 2016 Average Annual Capacity (MW) | 2002 – 2016 Average Annual Energy (GWh) | 2017 – 2050 Average Annual Capacity (MW) | 2017 – 2050 Average Annual Energy (GWh) | 2002 – 2050 Average Annual Capacity (MW) | 2002 – 2050 Average Annual Energy (GWh) |
|---|---|---|---|---|---|---|
| **Glen Canyon Powerplant** | | | | | | |
| Basin States Alternative | -10 | -5 | -1 | -16 | -4 | -13 |
| Flood Control Alternative | 0 | 0 | 0 | 1 | 0 | 1 |
| Six States Alternative | -10 | -5 | -1 | -15 | -4 | -12 |
| California Alternative | -21 | -16 | -1 | -35 | -8 | -30 |
| Shortage Protection Alternative | -21 | -14 | -1 | -36 | -7 | -29 |
| **Hoover Powerplant** | | | | | | |
| Basin States Alternative | -14 | 15 | -14 | -87 | -14 | -56 |
| Flood Control Alternative | 1 | 0 | 1 | 5 | 1 | 3 |
| Six States Alternative | -11 | 13 | -12 | -80 | -12 | -51 |
| California Alternative | -47 | 24 | -23 | -193 | -30 | -127 |
| Shortage Protection Alternative | -45 | 20 | -20 | -147 | -28 | -96 |
| **Total** | | | | | | |
| Basin States Alternative | -24 | 10 | -15 | -103 | -18 | -69 |
| Flood Control Alternative | 1 | 0 | 1 | 6 | 1 | 4 |
| Six States Alternative | -21 | 8 | -13 | -95 | -16 | -63 |
| California Alternative | -68 | 8 | -24 | -228 | -38 | -157 |
| Shortage Protection Alternative | -66 | 6 | -21 | -183 | -35 | -125 |

[1] Appendix P, Tables 8 and 10 compare each alternative to baseline conditions.
[2] Positive (negative) value indicates that cost is higher (lower) under the alternative.

At Glen Canyon, the greatest single-year difference in capacity compared to baseline conditions is 36 MW under the Shortage Protection Alternative (see Table 6 of Attachment P). This amount represents a decrease of 3.5 percent from baseline conditions and approximately 0.3 percent of the installed capacity in the Rocky Mountain Area. At Hoover, the greatest single-year difference in capacity compared to baseline conditions is 137 MW under the California Alternative (see Table 8 of Attachment P). This amount represents a decrease of 6.7 percent from baseline conditions and about 0.2 percent of the installed capacity in the three-state marketing area for Hoover.

Additional water releases resulting from four of the five alternatives (all but the Flood Control Alternative) under consideration will increase the energy available from the powerplants during the first two to seven years of the interim period. This can be expected to reduce energy purchases by the customers from alternate, higher priced resources. Future reductions in power production can be expected to necessitate increased purchases of capacity to meet peak loads and reserves. Purchases of replacement power by power customers would result in changes in costs and increased exposure to market volatility.

### 3.10.3 SOUTHERN NEVADA WATER SYSTEM LAKE MEAD INTAKE ENERGY REQUIREMENTS

This section discusses potential increases in operating costs of the SNWS Lake Mead intakes that could occur as a result of implementation of the interim surplus criteria alternatives. Increased pumping costs could occur if the alternatives cause lower Lake Mead water surface elevations than baseline conditions.

#### 3.10.3.1 METHODOLOGY

River system modeling, described in detail in Section 3.3, provided the average monthly elevation of Lake Mead for each year during the study period for baseline conditions and each of the alternatives. These elevations are shown in Table 2 of Attachment P. Increases or decreases in net effective pumping head correspond to decreases or increases in Lake Mead Surface elevations. The net effective pumping head differences between the baseline and the alternative strategies are also shown in Table 2 of Attachment P. Using an estimate prepared by SNWA (Johnson, 2000) for incremental pumping costs of $28,000 per year associated with each foot of increased pumping head, the increased cost of each alternative is shown in Table 2 of Attachment P.

#### 3.10.3.2 AFFECTED ENVIRONMENT

The State of Nevada, through the SNWA, diverts most of its allocation of Colorado River water from Lake Mead through the SNWS into the Las Vegas Valley and adjacent areas. The power-consuming features of this system are the pumping plants from Lake Mead to the water treatment facility. The energy required to provide this lift is a function of the net difference in elevation between the Lake Mead water surface and the water treatment facility. Any increase in the net effective pumping head would increase the amount of energy required to pump each acre-foot of water from Lake Mead. The net effective pumping head will increase as the Lake Mead elevation falls. Water users in Clark County, Nevada and possibly others would absorb increased costs associated with water supply.

#### 3.10.3.3 ENVIRONMENTAL CONSEQUENCES

The difference in net effective pumping head between each alternative and baseline projections is used to determine the effects of each alternative on pumping cost. The following analysis uses the estimate of $28,000 per year per foot increase in net effective pumping head furnished in the aforementioned letter. Baseline pumping costs were not calculated.

#### 3.10.3.3.1 Baseline Conditions and Alternatives

Under baseline conditions, the average elevation of Lake Mead declines from 2002 through 2050. These results indicate that under baseline conditions and each of the alternatives, SNWA can expect pumping costs to increase due to the increase in net effective pumping head. Table 3.10-2 summarizes potential differences between pumping costs under the alternatives and baseline conditions.

**Table 3.10-2**
**Southern Nevada Water System Lake Mead Intake Energy Requirements**
**Average Annual Power Cost – Comparison of Alternatives to Baseline Conditions[1]**
**(Differences between baseline conditions and each alternative)**

| Alternative | 2002-2016 | 2017 - 2050 | 2002 - 2050 |
|---|---|---|---|
| Basin States Alternative | $ 229,395 | $ 94,352 | $ 135,691 |
| Flood Control Alternative | $ -32,685 | $ -21,025 | $ -24,594 |
| Six States Alternative | $ 214,779 | $ 88,027 | $ 126,829 |
| California Alternative | $ 544,843 | $ 205,652 | $ 309,486 |
| Shortage Protection Alternative | $ 532,635 | $ 170,314 | $ 281,229 |

[1] $28,000/per year per foot increase in net effective pumping head at year 2000 price level
[2] Positive (negative) value indicates that cost is higher (lower) under the alternative.

The Flood Control Alternative, when compared to baseline conditions, results in reduced costs for SNWA to pump Colorado River water into its system. The Basin States and Six States alternatives result in average pumping cost increases of about $130,000 per year over the entire period of analysis. The California Alternative and the Shortage Protection Alternative result in average pumping cost increases of about $300,000 per year over the entire period of analysis.

## 3.10.4 INTAKE ENERGY REQUIREMENTS AT LAKE POWELL

This section discusses potential changes in pumping costs for two entities that pump water from Lake Powell: the Navajo Generating Station which obtains cooling water from Lake Powell, and the City of Page which obtains municipal water from Lake Powell. Incremental differences in pumping costs are associated with differences in modeled average Lake Powell surface elevations between baseline conditions and alternatives.

### 3.10.4.1 METHODOLOGY

River system modeling, described in detail in Section 3.3, provided the average elevation of Lake Powell for each year during the study period for baseline conditions and for each of the alternatives. Increases or decreases in net effective pumping head correspond with decreases or increases in Lake Powell surface elevations. Lake Powell elevations and the net effective pumping head differences between baseline conditions and the alternatives are shown in Table 1 of Attachment P. Estimates of the differences in pumping costs were calculated using these changes in pumping head, as well as estimates of annual water use, unit energy costs and pump efficiency.

The formula for calculating energy requirements (E) as a function of pump lift (H) is:

$$E = V * 1.024 * (H/e)$$

Where V is the volume of water pumped and e is pump efficiency.

### 3.10.4.2 Affected Environment

The Navajo Generating Station is a 2250 MW, coal-powered plant jointly owned by Reclamation, Salt River Project, Los Angeles Department of Water and Power, Arizona Public Service Company, Nevada Power and Tucson Electric Power. The Salt River Project (SRP) operates the plant. The SRP projects that water use will be approximately 29,000 afy in the future. Power for the intake pumps is obtained from auxiliary power units at the Generating Station at a cost of $0.0104 per kWh. Pump efficiency is estimated by SRP at 75 percent. (Weeks, 2000)

The City of Page provides municipal water to approximately 7800 residents from Lake Powell. The intake pump station is operated by Reclamation using power produced at the Glen Canyon Power Plant. Municipal water use in Page is dominated by residential use with substantial residential landscape irrigation. A negligible amount of treated water is delivered by the city to Reclamation for use at the dam. Presuming 275 gallons per day per resident, annual use would be approximately 2400 afy. An overall efficiency of 75 percent for the pump station was used as a reasonable estimate. A cost of $0.03 per kWh was estimated as the cost of the electricity.

### 3.10.4.3 Environmental Consequences

The difference in net effective pumping head between each alternative and baseline projections was used to determine the effects of each alternative on pumping cost. Baseline pumping costs were not calculated.

Under baseline projections, the average elevation of Lake Powell declines from elevation 3685 feet msl in year 2002 to elevation 3661 feet msl in year 2050 (Appendix P, Table 1) Table 3.10-3 compares the annual power costs of each alternative to baseline conditions.

As Lake Powell water elevations are within hundredths of a foot for baseline conditions and for the Flood Control Alternative, no change in pumping costs would occur. For all other alternatives, Lake Powell water elevations average less than under baseline conditions. Average pumping costs would be higher for both the Navajo Generating Station (average increase of $808 per year over the period of analysis for the Basin States Alternative) and for the Reclamation-operated raw water intake serving the City of Page. (Average increase of $193 per year over the period of analysis for the Basin States Alternative).

**Table 3.10-3**
**Intake Energy Requirements at Lake Powell**
**Average Annual Power Cost – Comparison of Alternatives to Baseline Conditions (Difference between baseline conditions and each alternative)**

| Alternative | 2002–2016 | 2017–2050 | 2002–2050 |
|---|---|---|---|
| **Navajo Generating Station Intake Energy Requirements[1]** | | | |
| Basin States | $ 2,216 | $ 186 | $ 808 |
| Flood Control | 0 | 0 | 0 |
| Six States | 2,129 | 172 | 771 |
| California | 4,651 | 303 | 1,634 |
| Shortage Protection | 4,660 | 312 | 1,643 |
| **City of Page Municipal Water Supply[2]** | | | |
| Basin States | $ 529 | $ 44 | $ 193 |
| Flood Control | 0 | 0 | 0 |
| Six States | 508 | 41 | 184 |
| California | 1,110 | 72 | 390 |
| Shortage Protection | 1,112 | 74 | 392 |

[1] E(kWh) = 1.024 * 29,000 * (H/0.75). Cost = E(kWh) * $ 0.0104
[2] E(kWh) = 1.024 * 2,400 * (H/0.75). Cost = E(kWh) * $ 0.03
Estimates are annual averages for the indicated time periods.